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July 16

No. 3. New Series. July 1877. [2s. 6d.

THE POPULAR Science Review

EDITED BY W. S. DALLAS, F.L.S.

Assistant-Secretary of the Geological Society.

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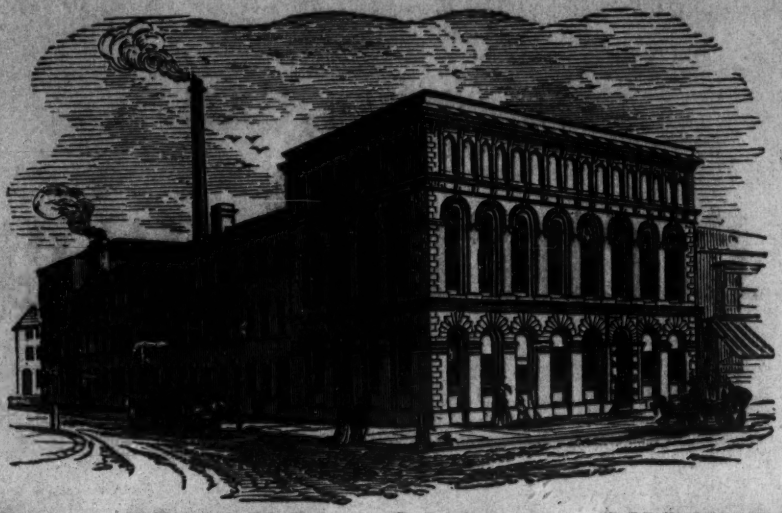

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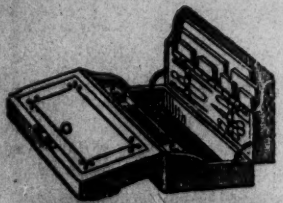

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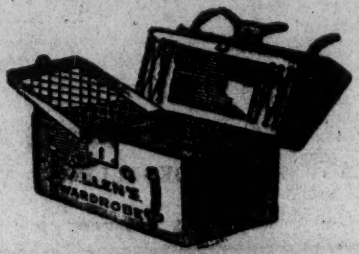

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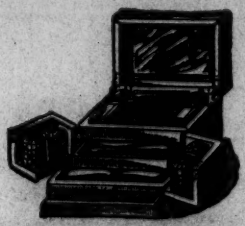

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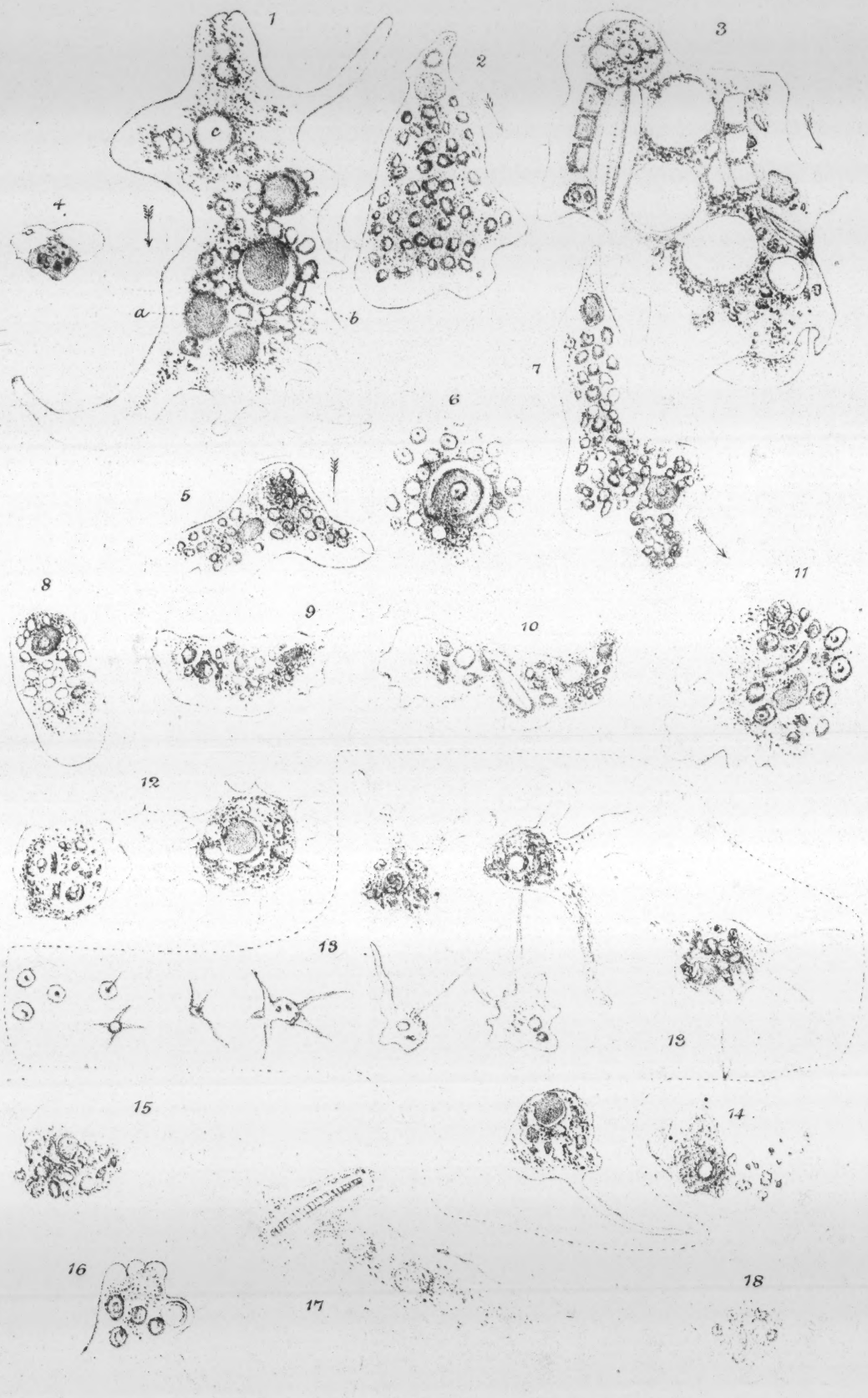

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Amœbæ.

STUDIES AMONGST AMŒBÆ.

By PROFESSOR P. MARTIN DUNCAN, F.R.S.
President of the Geological Society of London.

[PLATES V. AND VI.]

SHOULD a beginner in science wish to know what the very commonly repeated word Amœba represents in nature, he will, of course, seek for information in the numerous deep and superficial works on natural history of the day. A glance at the drawings given in half-a-dozen books will convey the impression that this creature is remarkably given to change its shape, for no two are alike; but unfortunately this unintentional truth is qualified by the fact that there is a singular want of conformity and unanimity in the written descriptions. Some naturalists will tell the inquirer that Amœba is an animal; others that it is a plant; and the very philosophical assert that it is neither, but that it belongs to the indefinite group of Protista. There is, however, a general belief that it is an exceedingly minute piece of protoplasm, being the lowest form of living thing; that it is constantly changing its shape, and protruding from one part after another, long or lobed projections called pseudopodia, with which it catches its prey; that anything over which it passes sinks in and is digested; and that it contains a nucleus, a contractile vesicle, and some vacuoles. It is usually stated that there is an outer coat with a doubtful membrane on it, and a granular inner mass which never runs into the pseudopodia. Finally, it is said to cast off its legs and divide, the separate pieces turning to perfect Amœbæ. The term "amœboid" is very constantly employed in explaining the movement, real or theoretical, of certain cells in the higher animals, and the idea is that it is a very slow, creeping, and changing one.

Described as it is, and drawn as it has been, in the books by which the young naturalist has to be taught, can there be the least reason or necessity for asking, What is the Amœba? Suppose the matter be looked into a little more deeply. It will then be found that some very admirable observers are by no

means in accord about the peculiar structure of Amœba, and that there is a great discrepancy of opinion regarding its mode of life, nature of movement, and manner of reproduction.

As the subject is important and yet by no means difficult, and as the anatomy and peculiarities of the Amœbæ can be examined by anyone possessing a good microscope and patience, the following studies have been brought forward in the order in which they were carried out, so as to assist any observer who may care to commence a similar course of investigation.

If anyone will go to Hampstead Heath, and, after enjoying the view over Harrow and Hendon, will walk down to the bottom of the valley which in summer is a mass of ferns and moss, he will find a small stream with a very boggy bank flowing at last into a pond. Here and there the running water flows over a rusty bottom, and moves long lines of confervoid growth in gentle waves. This is the home of Amœba, for there is pure well-aerated water and favourite food in abundance.

At the very outset of the investigation it is necessary to admit that Amœba comfortable, and Amœba in bodily discomfort may present very different appearances; and that a well-nourished individual, roaming in plenty of water and well supplied with air and food, will probably look very differently from one in a thin film of water with a piece of thin glass not very lightly put upon it. In fact, Amœba well fed, free, and natural, is a very different creature from Amœba cribbed, cabined, and confined, and anxious about things in general. The one moves along in a definite manner, has a meaning in its equally definite changes of form, and its life is long, and has a definite termination; the other is 'all abroad,' pokes out projections and retracts them in a most disorderly manner, and soon comes to a point in its career when its protoplasm loses its 'subtle influence,' and yet without molecular change, dies. This last is the type usually drawn in books, and it only slightly resembles the first. Then it is necessary to remember, before plunging into notes and drawings, that if the unborn young of the higher animals during their stages of growth, resemble animals simpler in construction than those which they will finally be like, some of the immature lower animals may resemble the Amœba. In other words, we must know that the Amœba-like thing we are going to work at, will always lead an Amœban life and die and reproduce Amœbas, and not turn to something else in its old age; or that it is the offspring of an Amœba. Moreover, in the study of the creature, it is necessary to speculate upon the possibility of Amœba having a romping childhood, a restless youth, and a ruminating senility; and that under the influence of exuberance of growth, the desire for amatory companionship, and the sedateness of old age, it may present many kinds of activities and

external habits. Certain it is, that when young the Amœba plays tricks and imitates some of its fellow creatures; that when middle-aged it roams about; that in its marriage two become one never to separate or part; and that late on in life it becomes rotund and quiet, and very unlike its old self.

There is generally not much trouble in finding the Amœbæ, for if they are in the water at all they are usually abundant. Their particular locality appears to differ according to the kind and age; and if for the sake of convenience they are grouped into three sets or types, one will be found in the midst of the minute miscroscopic algæ and confervæ on top of the mud; another will be noticed roaming over the tangled masses, and moving far and wide; and the third, more protean in its changes, is found everywhere on the glass, in the mud, and even floating for a moment or two in the midst of the water. Usually I have found the second kind (figs. 2, 7, 5) very common when the water and confervæ were fresh from the stream, and its activity is quite unlike what is usually called Amœban; but this very lively form, which rarely puts out long processes (pseudopodia), and the shape of which is often very sausage-like, soon becomes comparatively lazy, and permanently changes its shape into that of a disc or flat globe (fig. 8), which after leading a monotonous life increases in rotundity and bursts. It gives exit to a host of excessively minute globules, which are so many young Amœbæ.

In my first examination of some of the Hampstead water, in which some confervoid growth and a small quantity of bottom mud occurred, I used an ordinary glass slide, with a thin glass cover. There were two kinds of Amœbæ found within the field at once; one was the active form just alluded to, and the other was comparatively quiet. The quiet one may as well be noticed first, as its construction was very definite and clearly seen. It was looked at within a few minutes of its being placed on the glass, and then it presented the appearance of a ragged half-circle (figs. 9, 10) of very transparent faintly granular protoplasm, in the centre of which was a correspondingly shaped mass of granules, refractive globules, dark spots, and one or two clearish spaces of circular outline. The distinction between the two parts was evident enough, but there was no strict line between them, and on using an object-glass of one-eighth inch focus, the clear protoplasm was seen to enter between the granules and other constituents of the internal part, and indeed to be their medium. There was some slight movement on the free edge of the clear part, which may be called diaphane, and a ragged look was produced by a slight protrusion and a subsequent rounding off; and the internal mass (call it endosarc) had a motion going on within it which was peculiar. It was all edging away, so as to approach one angle of the diaphane;

then there was a movement of some of the granules and other microscopic bodies amongst the mass, like a flowing here and there, but still with a tendency towards streaming in one general direction; and the clearish circular space suddenly became obliterated, and slowly reappeared again, and enlarged. Soon the outside diaphane began to creep from the end of the endosarc, so that very shortly the Amœba assumed a relative condition of the diaphane and endosarc which was never subsequently lost (fig. 10). The endosarc reached to the edge of the Amœba in one part, and the diaphane kept to the opposite end, some slight film of it just encasing the whole, except now and then. Although the granules and other very visible matters usually kept away from the bulk of the diaphane, every now and then a rush would take place amongst them, and then the diaphane being made ragged by some projections of it, some granules would stream along towards and sometimes close to the diaphanous edge (fig. 4). The motion of the whole Amœba was in one general direction, the endosarc end being, as it were, dragged after the other. But the internal motion amongst the granules &c. immediately preceded the slow projection of a part of the diaphane; and as this was retracted, or as the whole body progressed beyond it, there was a return of the endosarc to its place of concentration. Very slow was this Amœba; and indeed, further experience, after the examination of many of them, proved that this dignified pace was more or less invariable. It never projected long processes, rarely took in food, and often rolled over most tempting things, things with which other Amœbæ are often crowded, but they did not sink into the mass and become dissolved. Its endosarc end, however, now and then adhered to minute broken-down organic matter and small diatoms, and they were dragged along with the whole. Now and then small portions were drawn in by the endosarc at one point where the diaphane was thinnest, but the proceeding was very tedious, so that the watching was long and tiresome before the green or red food was seen in and amongst the streaming and moving endosarc.

It appeared as if great care was required to take in the minute grain of food so as not accidentally to let out a quantity of the endosarc during its constant motion and streaming. The same slow process accompanied the getting rid of digested food and some minute spheres which were eventually to become Amœbæ. Then the endosarc projected so as to be covered with a very thin film of diaphane, and one of two things happened. Either some granules came close to the edge of the diaphane, and this was penetrated by a number of them (figs. 14, 15), or a very fine thread of granules pushed out a covering of diaphane far beyond the edge, and then the contents were

pushed through and the projection retracted. All this appeared to go on at one place, however, and that was the end remote from the onward moving diaphane. On a subsequent occasion, when examining this Amœba in a live box with a quarter-inch object-glass, a companion came creeping along, and as they were bound to come into collision I watched them with some interest. They touched at their diaphane ends, and it was evident that this protoplasm was not viscid, nor was it like thick gum or mucus. There was no external film or wall, but the diaphane of both creatures gave way a little, and no contraction or irritability was noticed. After a while the Amœbæ got clear of each other, and again came in contact in moving obliquely over the glass. This time the endosarc ends of both touched and expanded, and to my surprise the endosarc of one Amœba merged into that of the other, and the diaphane also. Was it cannibalism, or was it the very acme of love? The happy united, we can hardly say "pair," moved out of view gradually, and hid up amongst some shady confervæ (fig. 19). Towards the middle of August this kind of Amœba became very common, and careful watching showed that it was able to assume two phases, so to speak, of existence, one of which, as will be shown further on, referred to what the creature had been, and the other to what it would inevitably come to. With regard to the first phase, it was noticed that a small specimen, with the endosarc crowded with dark granules and minute spheres, and having a contractile vesicle, evidently had taken in minute diatoms, and had received, therefore, some pabulum, which it might expend in some physiological energy or other. The enlargement of the whole became evident, and the narrowing of the endosarc end also; but changes also occurred which were very interesting (figs. 21–25). A clear space became visible in the midst of the dark mass of granules, and it did not disappear, so it was not a contractile vesicle, but what is termed a vacuole, or water space. Then the movement of the Amœba became more active, and two blunt prolongations of the diaphane were projected, as if this clearish substance had suddenly poured out and consolidated. There were two pseudopodia, and their production was synchronous with a movement in the endosarc granules, as if these were going to flow out in the direction of the pseudopodia. The Amœba then drew in one pseudopodium, and another long one came forth on one side of it; then others followed from the same end of the creature, which began to progress vivaciously, and, in fact, to begin to lead the life of the active in-taking individuals, abundance of which existed in the aquarium.

About the same time that this change was noticed the dark endosarc of the Amœba began to be more diffused, so that the diaphane was constantly encroached upon by it; and the opaque mass

of granules became transparent here and there, so that the contractile vesicle, the vacuole, and a body hitherto unnoticed in this description, could be easily seen. This body was a globe surrounded by a dark line, in the midst of an almost complete circlet of light. On one side the little globular mass adhered to the surrounding endosarc; and elsewhere a clear fluid surrounded it and separated it from the granular mass. This is called the *nucleus*. Earlier in the season a number of Amœbæ (see series figs. 20–25 and fig. 13) had been examined which greatly resembled those of the active phase of the comparatively quiet form; and I have no doubt, after a study of sketches which were taken of them day by day, that they eventually turned into this quiet form. The end of the quiet form, which we may consider a phase in the life cycle of a thing very different-looking in its youth, appears to be two-fold, namely, a bursting or an encysting. Very considerable changes go on in the endosarc, such as the formation of large vacuoles and the development of more than one contractile vesicle, and the endosarc granules become diffused in the diaphane, to its edge. Then the whole assumes a globular form, and a sudden burst gives vent to the contents (fig. 26). Or the globular form may become perfectly motionless, or rather only the faintest wavy motion may be perceptible at the edge (figs. 29, 27), and induration of the thin film of diaphane occurs, and a kind of thin shell is formed to the whole mass. This encysted stage lasts for a few days in the glass cell, but it endures for a long time in the aquarium, and probably throughout the winter in many instances.

Keeping these changes of general shape in mind, let us consider the first active Amœba which was seen. This was a most exciting Amœba, and I confess to my astonishment at the pace the protoplasmic granular mass poured, I do not know a more significant phrase, along. It was, when first seen, in the shape of a longish cylinder, flattened at the end which moved in advance, and rather pointed at the opposite extremity, which was, as it were, dragged along (figs. 2, 7). There was no distinction between diaphane and endosarc, for the spherical granules, which were large and not abundant, were like currants in a dumpling. The diaphane was in excess, and was as usual nearly as transparent as water, tinted most faintly with neutral tint and very minutely granular. One of these transparent Amœbæ was one-fiftieth of an inch in length, and the streaming and rushing of the internal granules, and the coincident flowing out of rounded masses of diaphane (lobular pseudopodia), was constant and in every direction away from the small end. The grand current was central, and in the axis of the Amœba, and then when the granules came with a rush close to the very edge of the diaphane they turned outwards and then backwards, and on all

sides around the current, and so as to remount the outer part of the cylinder, again to be drawn into the central stream. This circulation was accompanied by liberal outflows of wonderfully transparent diaphane with rushes of granules and regressions, but the motion in the end was strongly in the one direction, namely, remote from the small end. The Amœba would expand and dilate, contract, and become sausage-shaped; and it would turn, but always with the one end first, and never with the small end in advance. So large and so active a creature resembled greatly an amœboid animalcule which has been called Pelomyxa, but it differs in many essential respects. It was a very wanderer—did not seem to settle down to take in food when surrounded with all sorts of things nice to others of its genus—and the sameness of the globular highly refractive bodies inside it was most remarkable. Evidently the constancy and the briskness of the movements, although no long processes or pseudopodia were ever projected, required a corresponding amount of sustentation. Perhaps this active Amœba was in a non-devouring phase of a complex life cycle. This last idea appears to be consistent with observation, for I traced one, through its 'fitful fever,' until it became quieter, more rotund: then at last, and to my surprise, the granular spheres collected more definitely together to form an endosarc which soon became central. Here, then, the active Amœba assumed the shape of that quiet form already described, but there was this internal difference—that the endosarc consisted of very refractive granules, globules, or spheres.

The protoplasm of the diaphane of the Amœba was undoubtedly clear, but in the mass was not so transparent as the rounded projections which were formed every now and then, but possibly this was caused by their thinness. Under a high magnifying power ($\frac{1}{16}$ immersion), a granular appearance was decidedly seen in it. A contractile vesicle was usually to be seen, and it was carried along in the moving inside. Now this shows that the comparatively clear protoplasm had a part of it severed, as it were, from the rest, and in the midst there was this curious power of opening out to form a space, and closing in with sufficient force to drive water out of it into the surrounding part. So refractive were the granular spheres which were scattered over the Amœba, within a thin film of diaphane, and so large was their central transparent part, that they resembled a host of small spaces or vacuoles, but their ultimate fate, which will be noticed further on, disproves this notion. A nucleus so faint that it can be rarely seen exists in this Amœba; but when it becomes apparent it is seen to be very transparent, and to be environed by a clear peripheral line except at one spot. In the figure (fig. 6) it is in the midst of a mass of the refractive granules.

The question of course arose, What was the early shape and what was the course of life of this very active Amœba? It could not be answered from the results of last year's work, but during the months of April and May of the present year the same stream-bottom yielded the required evidence. The smaller of these Amœbæ (fig. 28) seen moving about the confervæ and on the glass of a shallow live-cell box had all the characteristic movements of the form just described; but the minute creature had a very small end which never dilated or expanded like the opposite termination of the body, and an extremely actively moving pale endosarc. The movement was always with the broad end forwards. The bulk of the Amœba moved over things which made no impression on it, but the small end was sticky and often adhered to diatoms, and there was often a struggle between them, the affair ending in a sudden separation with a jerk. As these young forms were watched, it became evident that occasionally a minute spore or small navicula-like diatom coming in contact with the spot where the sticky end joined the non-adhering protoplasm of the diaphane, sank into the body, and was soon seen streaming along inside, environed by other prey, and a multitude of granules, granular spheres, and masses of protoplasm. These Amœbæ grew rapidly, and had an extraordinary power of finding food. They clung to the edges of the mud or confervoid mass in the cell, and if they accidentally roamed away, they began to move the front end first to the right and then to the left, stuck their small end downwards, and elevated the rest of the body and searched in all directions for something solid to touch. Every now and then a rush or flow of transparent diaphane would come out of the sides or large end, but never from the other; and part of the endosarc would often follow. But long sharp pseudopodia, or even long blunt ones, were never projected. As growth proceeded, several contractile vesicles appeared; and finally the form already described was assumed. Moreover, the final fate of this remarkable kind appeared to be that the quiet stage ended in one of encystment; that is to say, the outer part of the thin diaphane became more solid, the whole assuming the permanently globular form without movements. Then rupture of the side occurred after some days, and myriads of minute round masses with a spot in their midst escaped, each to develop into a tiny mobile Amœba.

It would appear that these two Amœbæ have the same kind of life cycle. First a minute globe of protoplasm with a translucent spot in the midst enlarges in diameter, and assumes an elongate form; then as growth proceeds, it becomes active, takes food at one spot, and moves in one direction. An endosarc with vacuoles and contractile vesicles becomes more and

more apparent, but still only arbitrarily divisible from the diaphane; and a nucleus is always present, although often seen with difficulty. As growth proceeds, one kind projects blunt pseudopodia very readily, and changes its shape constantly; and the other puts forth rounded flowings, but maintains its general outline. The first kind becomes quiescent, evacuates much, and even gets rid of granules, which are minute Amœbæ, and at last either bursts or encysts and bursts. The other kind has a roaming stage prior to its quiescent condition, which terminates in encysting, and subsequently in what may be called swarming of its included parts.

The commonest Amœba differs from the very lively form, and is so transparent and so slow in its ever-progressing change of shape that it may be readily passed over unnoticed when young. It occurs everywhere on the mud, vegetation, and on the glass, as well as occasionally in mid-water, where it has been wafted by the currents of some Vorticellæ or other whirling animalcula. Visible as a minute glairy spot when in its early stage, it may grow to $\frac{1}{25}$ inch in length, and then, when crammed with food, is a very fine object. Taking a large one as an example, it will be found that when on the glass (fig. 1) it looks very flat and very transparent, the endosarc hardly differing from the diaphane in its light-transmitting powers. Numerous projections of the diaphane (pseudopodia) are seen all around; some are blunt, and others are sharp, and several circular spaces readily transmitting light are to be noticed in the midst of it. After a while a languid movement occurs; a process is enlarged, another may move its free end, a new one is slowly protruded, and one of the clear spaces shuts up with a quick motion. By-and-by the creature begins to change its position, and then the invariable hand-shaped Amœban outline is assumed, that is to say, one end becomes smaller and the opposite larger; the largest pseudopodia and rounded occasional swellings are at the large end, which invariably moves first and in advance. Should any obstacle come in the way, the body flows on either side, and may spread out in a wonderful manner; but the small end has a greater density than the other, and does not give way, so that the movement takes place in a sliding manner round the object, and sooner or later the old and normal outline is seen. Many of the clear spaces in the endosarc are evidently not capable of contracting, but they are of all sizes, and sometimes a very large one may exist.

These vacuoles (fig. 1*a*) arise spontaneously or else are formed around some minute object which has got into the Amœba. They are digesting spaces. Amongst them may be seen a semilunar space (*b*), through which light passes readily, and it bounds a dark body which, although usually near the small end of the

Amœba, often travels about the endosarc. This is the nucleus, and it is made up of a less watery protoplasm than the rest of the Amœba, and has a structureless membranous coat surrounding it. Very often a clear space seems to appear and to move, but not in a manner resembling a contractile vesicle; and if the focus of the object-glass be altered and taken a little from off the ordinary level, a pseudopodium will be found sticking up from the Amœba and waving slowly in the water. It is the base of this fine projection which gives the appearance just noticed. As this Amœba moves slowly along it catches and sticks by its small end to the minute things which come in the way. The large end ever in advance moves over every obstacle around and under it, but the most tempting food never sinks in or is caught by it. The pseudopodia become very active with growth and more and more disposed to be large and rounded (lobose), but neither they nor the sudden outrushes of diaphane catch or include anything. A little watching will show that the spot where things are taken in is close to the small extremity, and that very often one or more pseudopodia are projected there, so as to encircle a diatom or a green animalcule or a piece of alga, which is slowly pressed by them against the Amœba and then sinks in. The prey becomes environed by a vacuole, or is tumbled about in the endosarc amidst the jumble of things there. It would appear that the pseudopodia, besides their locomotive use, give warning of good things being about; and if one of them should touch one of the long straggling threads of a Gromia, the whole Amœba will often change its direction of movement, gradually slip under the house of its prey, and the Gromia falls into the endosarc at the usual spot for the inception of prey. Every now and then, as this Amœba grows large, long lines appear to form on its surface (fig. 32), ridges of diaphane, which radiate more or less from the small to the large end; and, moreover, occasional collections of endosarc and food crowd the small end, and some granules and bits of digested food escape. Should one of these Amœbas, with its pseudopodia well put forth, come within the range of the current of a Vorticella, it is whisked off the glass and whirled here and there until it comes with a bounce against the disturber (fig. 30.) Now, it is a very important fact, and one which lets a great deal of light into the nature of the Amœban protoplasm, that no active or passive contraction should occur in it notwithstanding all this ill treatment. Just as when an animalcule with long cilia comes rushing against an Amœba, so, in the instance of the contact with the Vorticella, no evidence of contractility or irritability of the protoplasm is seen.

Growing day by day, especially if there is abundance of unicellular algaceous food, this fine Amœba finally has its en-

dosarc encroaching everywhere on the diaphane, so that a granular globular form surrounded by a thin film of diaphane is produced. Now this diaphane film plays all sorts of antics before settling down into a dense film of investment; it even pokes out long rays (figs. 34, 37), and tries to simulate the Sun Animalcule. But at last the delicate film becomes motionless and acts as a membrane around the globular mass, in which some movement may still be seen, and in which the nucleus is occasionally visible. The duration of this stage evidently depends on season, warmth, and the presence of much or little water; and it would appear that its commencement has a great relation to the prospective scarcity of food and water. As ponds commence drying up and algæ finish their spore-making, Amœba begins to think about the future, and soon encysts itself. This may be artificially brought about in May, June, and July in a little aquarium; and if the water is allowed to get low no active Amœbæ will be found, but lots of globes (fig. 27).

Although I had watched Amœbæ for a considerable time at intervals, and had had the same individuals living in a cell for days, a long time elapsed before I saw one cast off a pseudopodium which assumed an independent existence. It was one of the kind just noticed, and all the food that was within the endosarc was a great Pinnularia semi-digested. The Amœba was large, $\frac{1}{50}$th inch, and had evidently reached a critical point in its existence, for it was crowded with small granule-globules, and the only diaphane which was at all persistent was at the large end. Elsewhere the very fluid-looking endosarc appeared to have merged into diaphane. The Amœba rounded off its smaller end and then began to move as usual, broad end first, protruding diaphane first on one side and then on the other in lobose swellings. Suddenly it protruded, from the junction of the smaller end with the rest, a blunt pseudopodium which increased in size until it was two-thirds of the length of the whole, and then endosarc streamed into it (fig. 31). My attention was drawn to this rather unusual occurrence, and especially as a distinct round body got in as well. This was a nucleus; but whether the only one, or whether the original remained behind in the larger body hidden, could not be determined. All of a sudden the pseudopodium separated close to the body (fig. 35), which then altered its shape generally, and moved off. There was an escape of one granule-sphere only, and motion ceased in the cast-off member, which looked dead and flat. Presently the original free end of the piece began to move and project diaphane on either side, and a slight streaming of the granules and nucleus occurred in that direction. Then the ruptured end contracted, and two processes started from it, resolving themselves in a few seconds into a rounded small end (figs. 33,

33*a*). Here was a new Amœba, but as yet there was neither contractile vesicle nor vacuoles. It began to move actively, and got amongst some algæ, and was lost to view. It was a most startling proceeding, and would appear to be of rare occurrence. Absolute splitting in half, or what may be properly called fissiparity, I have not seen in Amœbæ.

As some of these Amœbæ gradually became quiescent it was possible to examine the nucleus, and by transferring them to a glass slide and employing a $\frac{1}{16}$th immersion object-glass, the structure of this remarkable piece of differentiated protoplasm could be pretty well made out. The nucleus (figs. 1*b*, 6, 36, 44) is usually darkish, not very transparent, and its investing structureless dense film is partly surrounded by a clear space; but, as age comes on, this space is often lost, and the little body is enclosed in a mass of granular protoplasm belonging to the endosarc. Then a small globule or nucleolus becomes readily visible within the nucleus (fig. 39). But it nevertheless sometimes happens that the clear space increases in size and completely surrounds the nucleus. In both instances it may be observed that the nucleus subdivides within its investing film, so that it appears to be a mass of closely-packed nuclei or small globes. Now these tiny globes greatly resemble some of the granule spheres of the endosarc, and as these are the rudiments of young Amœbæ it is quite possible that those of the nucleus will turn to independent individuals when the whole bursts.

It is incredible what a number of these tiny dots of granules escape from a good-sized Amœba when it bursts; hundreds of thousands move off from the mass and indulge in the fidgets of the Brownian movement until they increase in size and throw out a process and become masters of their movements to a certain extent (fig. 13).

One more Amœba must be noticed (figs. 38, 40); it is common up to a certain time of the year, becoming encysted before the hot weather sets in; or else it hides up amongst the mass of mud and tangled confervæ on the floor of the pond. It is only to be found in the waters which are tinted more or less with an iron rust colour; and as a rule it is so greedy and so constantly devouring its minute prey that it does not readily come out into the clear water of the cell. This Amœba may, therefore, readily escape notice. The first seen by me was half hidden under grains of dirt and a jumble of Desmidia and Pinnulariæ, and as the part visible resembled the ordinary Amœba just described, no attention was paid to it. But after a while a great flow of clear diaphane occurred from the mass, which was followed by a rush of granules into the rounded projection, the whole being in a very tumultuous state. Then a great cylindrical Amœba streamed forth, one end first as usual, and at the opposite end of the body

there was a narrowing, then a little neck and a round globular head covered with very minute, short, hair-like processes. This was something quite new, and it was very exciting to observe the curious movement of the body and the comparative steadiness of the curious neck and head. The diaphane was scanty near the head, but abundant at the opposite or forward-moving end; and the endosarc, dense, granular, and nearly opaque at the head and neck, became more diffluent elsewhere. The endosarc was in wonderfully active movement, pouring down the axis of the sausage-shaped thing, streaming out into the diaphane as it altered its shape, and approaching the very edge with active motion; then it turned backwards on all sides, so that a counter current occurred near the whole surface, the granules moving then towards the head. Then they entered the axis again, and could be followed about here and there until they got into the stream and rejected their former path.

No pseudopodia of any size came forth; but there was a lobular projection, first on one side of the forward-moving end and then on the other (fig. 38), the one being overwhelmed by the other as general movement progressed. Two or three small angular pseudopodia came out, and remained not far from the neck. Under a one-eighth inch object-glass the motion of the contents of the endosarc was very curious, and a good deal of it was independent of the contraction and dilatation of the diaphane and endosarcal protoplasm. The movements of the protoplasm produced great currents, but there was something going on like that movement which can be usually seen in the ends of the crescent-shaped green Closterium. As the Amœba moved along nothing got into it; and an animalcule came at full speed against its sides, but made no impression. After a while a change of shape occurred, the cylindrical form gradually merged into the hand-shaped (fig. 40), the head and neck still retaining their size and position at the end remote from forward movement. As the body flattened out, the nucleus became visible, and the contractile vesicle more distinct close to the junction of the head and neck. The minute long pimples, like stumpy hairs on the globular head, move, but do not increase in size except in length. I did not see any food taken in, and indeed the creature was pretty full; but after it had been in open water for an hour or so, it began to be uneasy and to move, wide end in advance, first on one side and then on the other, as if seeking for something to eat or move amongst, and finally it disappeared under some conferva.

The next of this kind I saw feeding. The creature came out of a mass of vegetation with a bundle of minute things sticking to its head, and it dragged its load about until finally something stopped the way and the head made its appearance. There was

then a movement of pulling before the evidently very sticky short hair-like processes would condescend to give way (fig. 40). They did at last, having been more or less elongated, and there was a decided and active expression of relief in the jerk-like onward movement of the Amœba. The creature had several of the short, wedge-shaped pseudopodia close to the neck, and as it turned to reconsider its bundle in a very unautomatic manner, those of one side came in contact with some broken-down granules and conferva cells. The pseudopodia closed on the granular mass and brought it to the part where the neck of the head joined the main body, and the prey sank into the endosarc. I have repeatedly seen these Amœbæ take in food, and it has always been at this particular spot.

Growing to a large size for Amœbæ, these tufted ones are by far the most interesting to observe, and there is no doubt that they have the usual life-cycle of the group. The last I watched disappointed me sadly. It had grown corpulent and sluggish, and I trusted that it was about to encyst, but suddenly it assumed the spherical shape, the head and neck were lost in the general rotundity of the surface, and then the mass burst at one spot, and endless granule-spheres came out. The young of this Amœba have the head-tuft at a very early age, and, like the old, never move head first. Like the other Amœbæ they now and then play antics, change their shape, cling on by one long leg and cast out others, then pull all in, and sail off in the shape of a sausage or a hand with the fingers extended.

The parts of an Amœba are its diaphane and endosarc; the nucleus, the contractile vesicles and the vacuoles are invariable structures; and the granule-spheres and some odd crystalline-looking grains are seen in varying quantities. It is evident that there is no positive distinction to be made between the diaphane and the endosarc, and one can become the other; but the nucleus is a special structure, and has its investing film and a nucleolus.

When the smallest Amœba visible with the highest powers of the microscope is watched for a minute or two, a tiny spot, usually not far from its centre, will be seen to enlarge, remain, and then suddenly disappear. If the object be still observed, the spot will be found to re-appear as a point and then to enlarge and pursue the same course. Larger Amœbæ and the very largest also present one or more of these dilating and shutting-up spots in their midst; and certainly the more they are watched, the more does their extraordinary character impress itself upon the observer (fig. 1*c*). The spot is in the denser substance of the Amœba, but one may often be seen so close to the edge (fig. 16) that it must be in the diaphane. It is spherical in shape, and therefore circular in outline, but the pressure of the moving

granules in their rushes and streamings may alter the shape for a while; there is no limiting or enclosing membrane, but in large Amœbæ, where this contracting bladder or vesicle is very visible indeed, something like a rough edge appears within. Evidently the light traverses the spot more readily than it does the surrounding protoplasm, and this is due to its being filled with a more highly refracting medium—water. The water coming from somewhere collects as the protoplasm expands actively from a point-like space; and then when it contracts more actively in a more or less observable rhythm, the water is expelled and goes somewhere. This pulsation, or what the doctors would call systole and diastole, occurring in a structureless material, is as incomprehensible as the outside change of shape, and the protrusion and retraction of the pseudopodia. The active expansion would suck in water from the surrounding mass, and it appears to do so generally, and not through any canals or conduits; and the sudden and very vivacious contraction must, one would think, rupture the surrounding soft material unless there were permanent minute porous tubes in it. On watching with the highest powers no displacement of the surrounding granules can be noticed after one of these active closings of the contractile vesicle; but they sometimes precede a new movement in the general mass, such as the commencement of a streaming in a new direction, or the emission of a transparent lobose or sharp pseudopodium. In some instances the vesicle is moved along with the rest of the endosarc, and contracts and dilates in the midst, so that it is impossible that there can be any permanent outlet between it and the surrounding water. But when the vesicle is in its very common place, close to the food-entering end, there is sometimes an appearance as if there was a direct discharge through the diaphane into the surrounding water. But I must confess that no motion occurs amongst the minutest particles which may surround the end of the Amœba synchronously with the active contraction of the vesicle. Corresponding vesicles occur in the Sun Animalcule which abounds in the water containing the Amœbæ, and these occur on the very edge of the protoplasmic mass, bursting with such force as to shake the creature. The exit of their contents into the surrounding medium is visible enough, but this is not observed in Amœbæ.

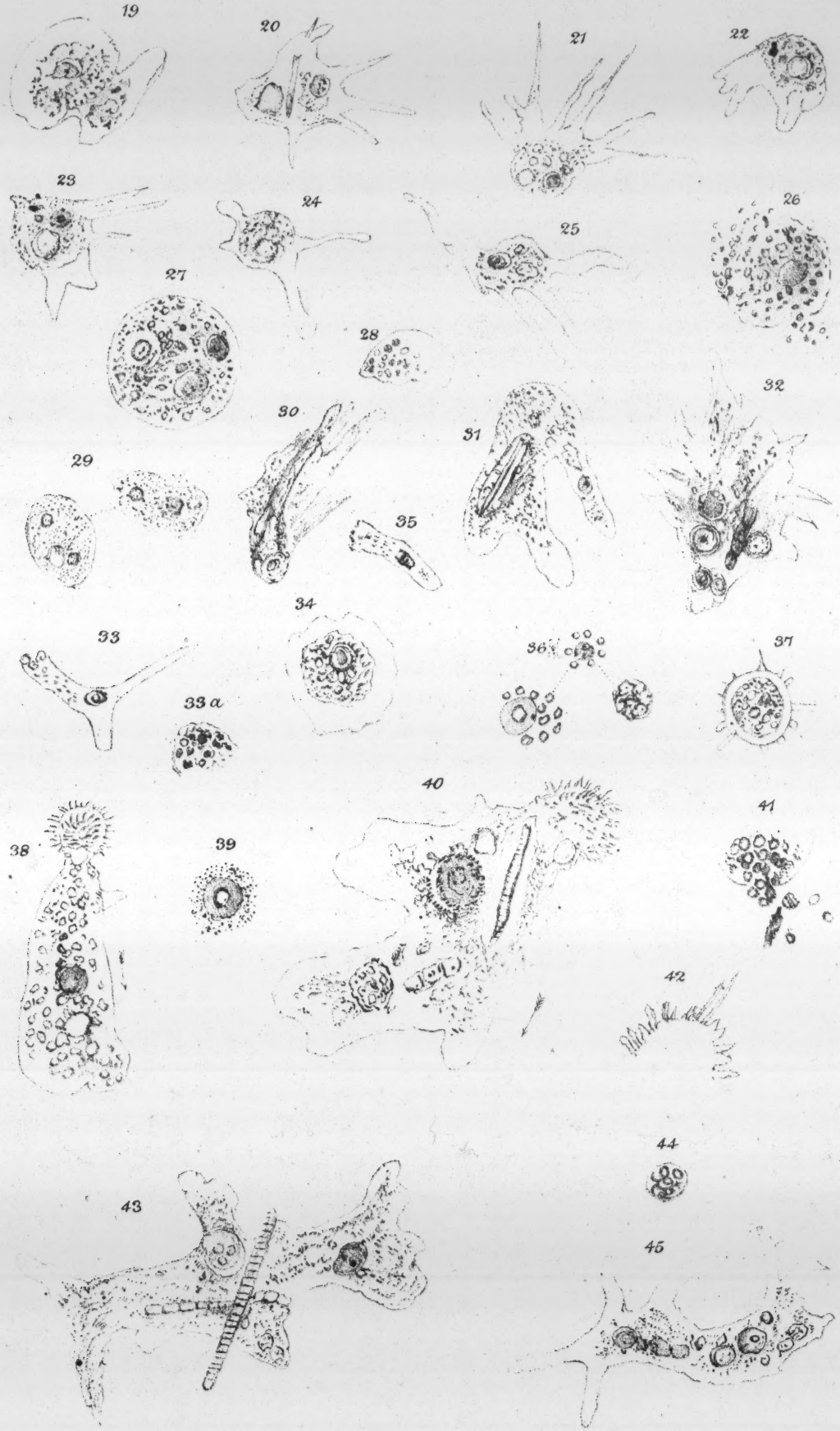
Sometimes, when there are two contractile vesicles, they unite, and one large spot is produced which either assumes the spherical shape or remains irregular in outline until it contracts and disappears. Under all conditions, and whether the Amœba is flourishing or dying from inanition and pressure, the contractile vesicle enlarges to its full size slowly in comparison with the sudden contraction, but the frequency of the pulsation,

if it may be so called, appears to relate to the health of the creature. The vesicle may be seen stationary for a long time when the empty endosarc, with hardly a trace of food in it, is pale, and not very distinguishable from the diaphane, but when the whole is well nourished the vesicle appears and disappears with remarkable regularity.

The function of this extraordinary arrangement is probably in relation to respiration and circulation. Either the contents which are drained or sucked out of the surrounding endosarc are water, or water and very liquid stuff which will eventually become endosarc or diaphane; the contraction redistributes the water, and pumps the results of the simple digestion, diffused, as it has been before, again into the mass. But it has been observed a few lines back that some change in the direction of the streaming of the endosarc, or the protrusion of a pseudopodium, frequently occurs immediately after the contraction of a vesicle, so that it is quite possible that its function refers to the diffusion of a nutritive liquid as well as of simple water. All animalcules, and a great many small moving things which are classified as water plants, have these vesicles, and whilst in some they burst through a tube or directly into the surrounding water, those of others, in some rare instances, force their contents through radiating canals into the body of the creature. It would appear that a definite mass of endosarc always maintains itself around the vesicle; and therefore it follows that one particular mass of the protoplasm of the creature is endowed with a permanent function, and a power of dilating and contracting with rhythm.

On the other hand, vesicles appear where formerly they were not, so that it must be admitted that this interesting power of radial expansion and concentric contraction is common to the tissue of the Amœba generally, and that it is a specialized gift analogous to the ordinary protrusion of the diaphane, and its retraction and curving point in one direction and then in another.

A large Amœba with a very delicate endosarc had been feeding on broken-down conferva, spores, and green cells, when a tolerably large diatom (fig. 17), a Pinnularia, came in contact with its small end. The scanty diaphane then immediately increased in quantity and flowed over the intruder, which sank, as it were, gradually into the endosarc, and remained in one part of it. After a few minutes had elapsed, a clear space formed in the Amœba around the prey, which immediately began to move in it forwards and backwards after its usual fashion. The space was evidently filled with water, and therein moved the captured diatom, apparently in no great discomfort. After long watching it became apparent that the size of the space, or *vacuole*, as it is termed, increased, and that the diatom became



F. M. D. del.

W. West & Co. imp.

Amœbæ.

stationary and ragged-looking, and in the course of more than a day it split and separated into two halves. After this the vacuole disappeared, and the relics of the meal were jumbled up in the group of granules and other digested bits which streamed about in the endosarc.

Anyone can see what has been just described, and the whole life-history of Amœba can be followed with ease with ordinary appliances. If a young microscopist has satisfied himself that all that has been stated is true, he will stand in the same position with regard to myself that I do to a great many English and foreign observers. All that has been noticed in these studies will be found somewhere or other, and I found it most interesting and instructive to study the work of Dr. Wallich, in the "Annals and Magazine of Natural History," for 1863. There the hairy Amœba is admirably described, and christened *Amœba villosa*, and all its oddities are explained; there the reciprocal nature of the endosarc and diaphane, the nature of the nucleus and the method of its sub-division, and indeed the exact morphology of the Amœbæ is given to perfection. Carter, Carpenter, and Williamson have discovered and described much, and many species have been made and described by them and by learned Germans. One thing has struck me, and that is that there are two species of Amœba only, and not a score. There is *Amœba villosa*, which is really a "crowned head" (figs. 38, 40). Then there is the other, which according to locality, time, season, food, and the eyes of the observer, changes its general shape and receives many names, but it is the common form at Hampstead, and is called *Amœba princeps*. It ought to be *Amœba communis*, as it is plebeian to the regal *Villosa* (figs. 1, 2, 3, 7, 9, 10, 13, 21, 22, 30, 31, 40, 41).

DESCRIPTION OF PLATES V. AND VI.

The arrows point in the direction of movement during regular progression.

FIG. 1. A large Amœba with contractile vesicle, nucleus and much food.
FIGS. 2 and 7. A large and very active Amœba (a peculiar stage).
FIG. 3. Amœba, comfortable, and full of food and large vacuoles.
„ 4. An Amœba with endosarc reaching edges of diaphane.
„ 5. The same, with general shape changed. Nucleus shown.
„ 6. Nucleus, nucleolus, and granule-spheres.
„ 8. Commencing quiescence before encystment. Sarcoblasts of Wallich.
„ 9. Amœba with endosarc in the midst (a peculiar stage).
„ 10. The same, assuming the normal shape.

FIG. 11. The edge magnified (one-sixteenth immersion), showing ragged diaphane, and sarcoblasts, or granule spheres.
„ 12. Amœba imitating Actinophrys before encystment.
„ 13. Development of Amœba from a granule-sphere.
FIGS. 14, 18, and 41. Digested food and granule-spheres escaping.
FIG. 15. Endosarc and food close to the margin.
„ 16. Contractile vesicle expanded and close to the edge.
„ 17. Vacuole containing a moving Pinnularia.
„ 19. Contact previous to union of two Amœbæ.
„ 20. Amœba with large contractile vesicle, small nucleus, and several pseudopodia.
FIGS. 21, 22, 23, 24, and 25. Amœbæ under different circumstances.
FIG. 26. Amœba bursting and giving forth sarcoblasts or granule-spheres.
FIGS. 27 and 29. Encysted Amœbæ.
FIG. 28. A small active Amœba, formerly inactive.
„ 30. Amœba floating free.
„ 31. Amœba with a nucleus in a pseudopodium.
„ 32. A large Amœba with radiating ridges of diaphane.
FIGS. 33 and 33*a*. The growth of the head end of the new Amœba.
FIGS. 34 and 37. Imitating Actinophrys before encystment.
FIG. 35. Pseudopodium cast off.
„ 36. Nuclei.
„ 38. Amœba villosa, *Wallich*.
„ 39. Nucleus.
„ 40. Amœba villosa.
„ 42. Margin of "head," showing hairy projections after contact.
„ 43. Amœba (the common one) uncomfortable.
„ 44. A nucleus.
„ 45. Moving off.

MARS IN THE AUTUMN OF 1877.

By RICHARD A. PROCTOR, F.R.A.S.

[PLATE VII.]

IN the years 1867 and 1869 I discussed in these pages the relations presented by the planet Mars during the oppositions of those years, when the planet was traversing the aphelion portion of his orbit. Since that time several observations of interest have been made upon Mars. Moreover, Dr. Terby of Louvain has brought together many observations, made since the year 1630, but which had before been scattered in the Proceedings of learned Societies, in the private notes of observers, and elsewhere in such sort as not to be directly available to science. I may remark, indeed, in passing, that we find illustrated in this case what I cannot but regard as a serious disadvantage of the action of learned Societies. Enabling observers, as these Societies do, to publish the results of observation, the Societies do good work; for many observers could not otherwise perhaps afford the expense of making their work known as it proceeds. But in several cases it has happened that this piecemeal issue of important labours has prevented the publication of the entire series, revised and corrected by the observer himself. For example, we no doubt owe a debt of gratitude to the Royal Society for publishing the successive papers on the stars drawn up by Sir W. Herschel; yet no one can doubt that if it had so happened that Sir W. Herschel had been compelled to wait until his labours were concluded, or at least until each successive stage of his progress had been completed, and had then presented his work to the world, its value would have been enhanced tenfold, though probably he would have been put to no small expense, which the Royal Society saved him. In the case of observations made on Mars, we have not the results of any single observer's work presented in detail even in the Proceedings of Scientific Societies, only a few selections here and there, such as the observer thought most likely to be published for him; or, in some cases, a few only from among these. Thus,

we have not any complete account of the observations made by Schröter, W. Herschel, De la Rue, Dawes, and a host of other observers, but only a few fragments here and there. I venture to say that the work done by Dawes alone upon Mars, if it had been brought together by himself and published as a book, would have done more to throw light on the planet's condition than such scattered selections from the labours of a dozen of the best observers (including himself) as are alone available to us under the present system.

It will be well, before proceeding to consider the features to which telescopists should direct their attention during the approaching opposition of Mars, to note the order in which favourable and unfavourable oppositions of Mars succeed each other. The coming opposition, as most of my readers doubtless know, is one of the most favourable of the present century. The planet will not be quite so near to perihelion, at opposition, as he was in 1845 (when, by the way, many observations of interest were made); but he will be more favourably situated for observation in our northern hemisphere, because of his less southerly declination. In 1830 he was more favourably placed in this respect (being nearly on the equator at opposition), but further from perihelion. In 1892 he will be at once further from perihelion and less favourably placed. These oppositions (1830, 1845, 1877, and 1892) are the nearest to perihelion during the present century; after them come, in order of distance, 1862, 1860, 1847, 1879, 1875, 1864, 1890, and 1881.

It is easy to ascertain the circumstances which determine the recurrence of oppositions in favourable and unfavourable positions.

The sidereal period of the earth being 365·2524 days and that of Mars 686·9797 days, in order to determine the varying position of oppositions we must in the first place consider the improper fraction $\frac{6,869,797}{3,652,524}$, and, presenting it as a continued fraction, obtain from it a series of fractions approaching it more and more nearly in value. (The remainders obtained in this process all represent the number of days by which various multiples of the sidereal year and the sidereal period of Mars differ from each other.) We obtain:

$$\frac{6,869,797}{3,652,524} =$$

$$1+\cfrac{1}{1+\cfrac{1}{7+\cfrac{1}{2+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{3+\cfrac{1}{1+\cfrac{1}{1+\cfrac{1}{7+\cfrac{1}{1+\cfrac{1}{6+\cfrac{1}{2+\cfrac{1}{5+\cfrac{1}{3+\cfrac{1}{1+\cfrac{1}{3}}}}}}}}}}}}}}}}$$

(I commend the prevalence of 1's, 3's, 7's, and 2's in this result, and the absence of 4, 8, and 9, to the special attention of all who find strange significance in the excess of 3's and the

paucity of 7's in the number representing the ratio of a circle's circumference to its diameter.) The corresponding fractions are $\frac{1}{1}$, $\frac{2}{1}$, $\frac{15}{8}$, $\frac{32}{17}$, $\frac{47}{25}$, $\frac{70}{42}$, $\frac{284}{151}$, $\frac{363}{193}$, $\frac{647}{344}$, $\frac{4892}{2601}$, $\frac{5539}{2945}$, &c.; and the corresponding relations, which chiefly concern us, are these:

1 sid. per. of Mars − 1 sid. year	=	321·7333 days
2 sid. years − 1 sid. per. of Mars	=	43·5331 „
8 sid. per. of Mars − 15 sid. years	=	16·9916 „
32 sid. years − 17 sid. per. of Mars	=	9·5499 „
25 sid. per. of Mars − 47 sid. years	=	7·4417 „
79 sid. years − 42 sid. per. of Mars	=	2·1082 „
151 sid. per. of Mars − 284 sid. years	=	1·1171 „
363 sid. years − 193 sid. per. of Mars	=	0·9911 „
344 sid. per. of Mars − 647 sid. years	=	0·1260 „
4892 sid. years − 2601 sid. per. of Mars	=	0·1091 „
2945 sid. per. of Mars − 5539 sid. years	=	0·0169 „

So that between the time of the opposition of Mars which occurred in the year 3662 B.C. until our earth came to the same part of her orbit (not the same part of the year of seasons, but of the sidereal year) Mars will have made 2945 sidereal circuits *plus* his motion in 0·0169 days, or in 24 min. 20·16 seconds. This is the nearest periodic approach (I refer to the near equality of 2945 periods of Mars and 5539 years) during what is commonly regarded as historical time; since the next fraction after $\frac{5539}{2945}$, derived from the continual fraction above given, has for its numerator $5539 \times 6 + 4892$ or 38,126, which is the number of sidereal years of the corresponding relation between the periods of the earth and Mars: 20,271 sidereal periods of Mars fall short of this long interval by ·0077 days, or 11 min. 5·28 sec. Beyond this we need not care to proceed.

The use of the relations above tabulated will be very obvious. It shows first the number of years separating similar oppositions of Mars, the closeness of the similarity depending on the smallness of the number of days representing the difference between so many years and the corresponding number of periods of Mars. Thus we see that in fifteen years from any given opposition, Mars is removed seventeen days' journey from the prolongation of the line extending from the sun to the earth. That line, or the earth's radius vector produced, has passed Mars recently therefore, and we have to carry it back at the earth's daily rate of angular motion round the sun, carrying Mars back by his less rate of motion, until the earth's radius vector passes through Mars, to get the place of opposition, which of necessity precedes the place of opposition fifteen years before. Since the earth's mean daily rate is 3548″·193, and Mars's 1886″·518, the difference, 1661″·675, is the earth's daily gain; and we have only to find out how often this is contained in 17 (or more exactly

16·9916) times the daily motion of Mars, 1886″·518, to find by how many days on the average the date of the later opposition precedes the date of the earlier. We find the average difference of date to be about $18\frac{1}{3}$ days. But owing to the considerable eccentricity of the orbit of Mars and the consequent variation of his daily motion, the difference of date largely exceeds this value for oppositions occurring near perihelion, and largely falls short of it for oppositions occurring near aphelion. For instance, the opposition of 1862 occurred on or about October 5, while that of the present year—fifteen years later—occurs on September 5, thirty days earlier. On the other hand, the opposition of 1869 took place on February 13, while that of 1884 will occur on or about January 31, about thirteen days earlier.

In a similar way the closer approach brought about in thirty-two years, and the still closer approach brought about in forty-seven years, can be dealt with.

The approach brought about in seventy-nine sidereal years is so much nearer that it merits closer attention. We have the general relation that seventy-nine sidereal years exceed forty-two sidereal periods of Mars by 2·1082 days (or 2·1 days, nearly enough for our purpose). And we have for the average case, of course, the same daily motions as before; whence the average number of days by which an opposition in any given year falls later than one occurring seventy-nine years before is equal to 1886″·518 × 2·1 divided by 1661·675 or about 2·4 days. But when Mars is near perihelion his daily rate of motion is about 2286″, while the earth in the corresponding part of her orbit has a daily rate of about 3470″; consequently, the daily gain of the earth is about 1184″ only, with which gain a difference of 2·1 times 2286″ has to be made up. Hence we have for the interval in days between two oppositions occurring near perihelion and separated by seventy-nine years 2·1 times 2286 divided by 1184 or 4·14 days. On the other hand, when Mars is near aphelion his daily rate of motion is about 1576″, while the earth in the corresponding part of her orbit has a daily rate of about 3636″, so that the earth's daily gain is 2060″, with which gain a difference of 2·1 times 1576″ has to be made up. Hence we have for the interval in days between two oppositions occurring near aphelion and separated by seventy-nine years, 2·1 times 1576 divided by 2060 or 1·66 days. (The date of the later opposition follows the date of the earlier.)

The approaching opposition is important in two chief respects. First, it affords a favourable opportunity for determining the sun's distance: and secondly, it will be possible to study under very favourable conditions the southern hemisphere of Mars.

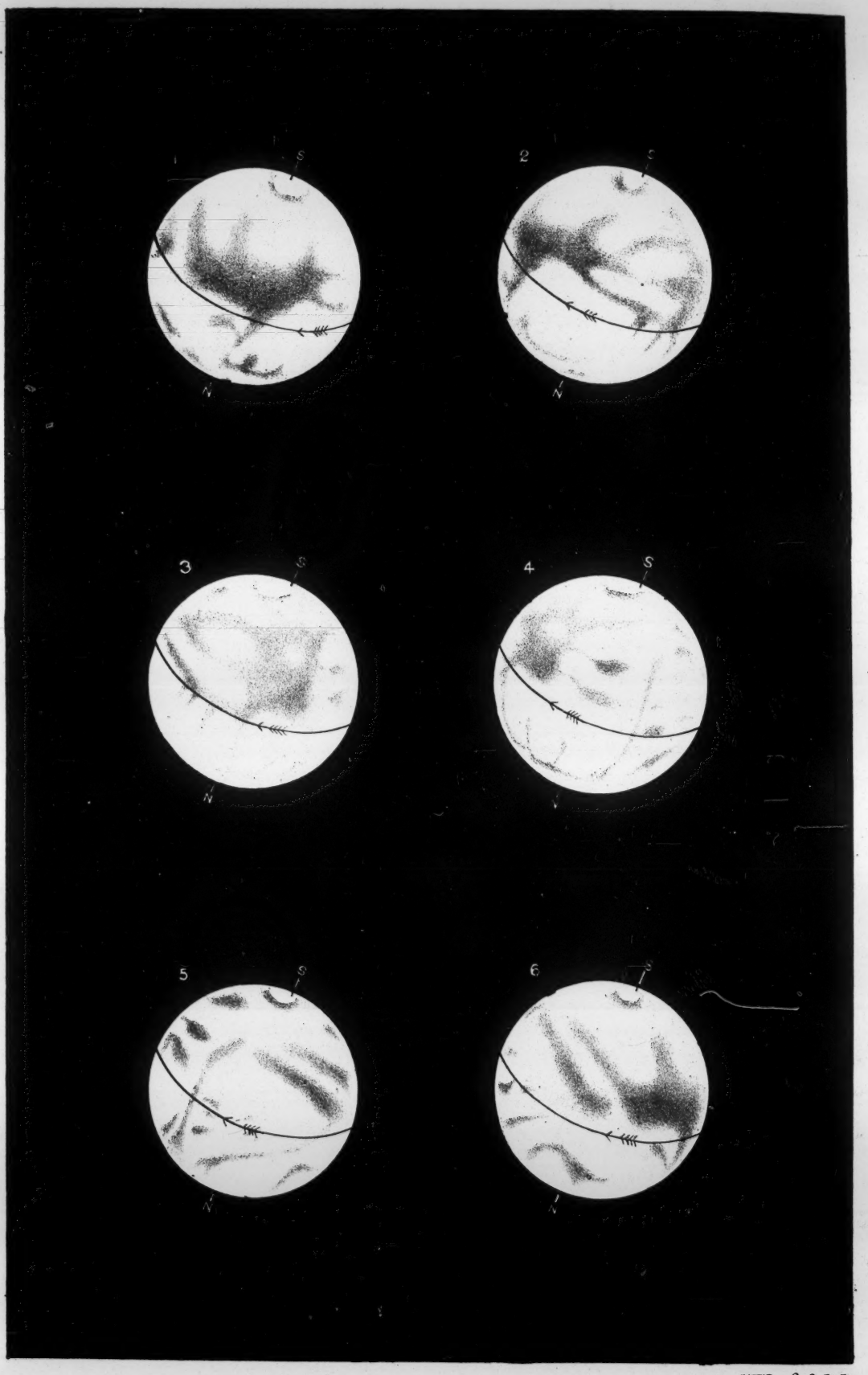
On the first point it is not necessary to say much here. I have already entered somewhat fully into the merits of this par-

ticular method of determining the sun's distance in Chapter I. of my treatise on the Sun. I believe it will be found that the observations to be made next September by this method will afford measures of the sun's distance comparing favourably with those obtainable by any other methods, including the observation of Venus in transit. It is unfortunate that official astronomers in this country have not endeavoured to obtain the sanction of Government for any expeditions by which advantage could be taken of the near approach of Mars. But it must be remembered that, being themselves in the receipt of money from Government, they naturally feel some delicacy in advocating the outlay of Government money on the observations of special phenomena outside the routine of work in the public observatories. It is understood, too, that apart from any question of delicacy, Government observers have lately had good reason for avoiding any suggestions in favour of expenditure on scientific expeditions, very plain hints having been given them that it does not fall within the duties of their office to make such suggestions. Be this as it may, it is certain that the only expedition for observing the approaching opposition of Mars is one undertaken by Mr. Gill, who managed very successfully the heliometric observations of the transit of Venus at the Mauritius (Lord Lindsay's transit expedition). For this expedition a sum of 500*l.* has been provided by the Astronomical Society, and the fine heliometer used in 1874 has been lent by Lord Lindsay.

The observation of the features of the surface of Mars, though not a task of equal difficulty, is one of nearly equal scientific importance. Whether the Sun is a few hundred million miles nearer to us or farther from us than had been before supposed, is in reality a matter of very little moment. The exact determination of the Sun's distance, if it could be effected, would not have the least practical value, and in this sense would not be one whit better than the determination of the true shape and position of the lands and seas of Mars. There is a meaning, indeed, in every change in our estimate of the Sun's distance, which is full of interest for the student of nature; but surveying astronomy, so to describe the work for which Government observatories are established, could get on quite as well if the Sun's distance were erroneously estimated by many millions of miles, as if we knew the distance to a hair's breadth. Certainly the determination of the physical features of a planet is not devoid of interest for the student of science; it enables us to judge of the planet's actual condition, to compare the planet with our earth, to draw inferences respecting the influence of a planet's size, mass, and position on the progress of those various changes which constitute the life-history of the planet. Indeed, I do not hesitate to say that if we could obtain exact knowledge

respecting the physical condition of the Moon, Mars, and Jupiter, the information would largely surpass in real interest the most correct determination of the Sun's distance. If any proof of this were needed, it would be found, I conceive, in the fact that every piece of information obtained respecting the physical condition of the planets is at once recognized as full of significance, whereas when a change has been made in our estimate of the Sun's distance, corresponding changes are made in the numerical relations indicated in our text-books, and that is all. No suggestions are made, and indeed none seem needed, to the effect that we must modify views formerly entertained respecting either the Sun or the members of his family. The determination of the Sun's distance, in fact, is a problem of surveying and statistical astronomy, not of that living astronomy, which alone has any interest for us as reasoning inhabitants of one of the worlds which fill God's universe.

The aspect which will be presented by Mars as seen in the telescope will not differ greatly at any time during the approaching opposition from that indicated in the six illustrative projections (Pl. VII.). These represent six stages of Martian rotation, separated by 60°, or by 4 hours of Martian time. On Sept. 5, Mars comes into opposition at midnight. At this hour the Martian meridian crossing the centre of the disc of Mars will be very nearly in 26° east Martian longitude, or the meridian passing some 15° east of Dawes' Forked Bay in the accompanying chart (p. 245). The view nearest to this in the series of six is No. 2, in which the central meridian is in 30° Martian longitude east. The rotation of Mars occurring in the direction shown by the arrow, and one degree of rotation being completed in about 4m. $6\frac{1}{4}$s., it follows that the aspect shown in No. 2 will be presented at about $16\frac{1}{2}$ minutes before midnight Sept. 5. The observer will have no difficulty in determining when the other views may be looked for. On any the same night, the interval between one view and the next amounts to about 4h. 6m. 14s. (the rotation period of Mars being 24h. 37m. 22·7s.); and neglecting the angular motion of Mars about the earth, which in such a case we may do for short intervals of time, any view changes nearly into the *preceding* for the *same* hour of the night in the course of six nights. For, in each terrestrial day the planet completes one rotation, less the amount of rotation corresponding to 37m. 22·7s., and six times this daily loss of rotation gives the rotation corresponding to about 3h. 44m. 16s., or only 22m. short of the amount corresponding to one-sixth of a Martian day. In seven days, the loss corresponds to 4h. 21m. 39s., or only about $15\frac{1}{3}$m. more than the amount corresponding to one-sixth of a Martian day. Thus, neglecting his angular motion round the earth, Mars presents



W. West & Co. lith.

the aspect shown in No. 1, six days less 22 min., or seven days *plus* $15\frac{1}{2}$ min. *after* he had presented the aspect shown in No. 2.

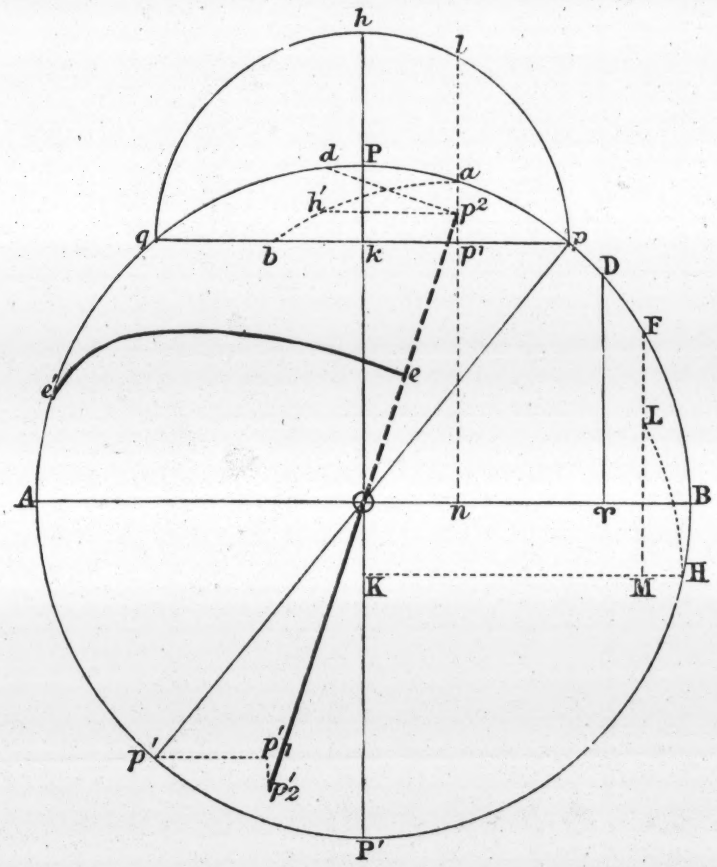
It may, however, be convenient to the observer to introduce the correction for Mars's angular motion round the earth, which, indeed, though small for the motion of Mars during six or seven days (even) when he is in opposition, necessarily becomes appreciable in the course of several weeks, during which the planet is favourably placed for observation before and after opposition. The correction can readily be made as follows. From the "Nautical Almanac" mark in the position of Mars at intervals of ten days (say) in any atlas showing longitude and latitude. (In my "School Atlas" the longitude and latitude lines are indicated by their points of intersection to every 30°; but it will be found easy to fill in, on a tracing taken from the proper map, the intermediate longitude and latitude lines to every 5° or 10°). Thus the geocentric motion of the planet in longitude is indicated. Direct motion in geocentric longitude delays *pro tanto* the coming of a Martian meridian to the centre of the disc of Mars, while retrograde motion in geocentric longitude hastens *pro tanto* the arrival of a Martian meridian at the centre. For instance, suppose that on a given day soon after opposition Mars has retrograded $\alpha°$ in longitude from his opposition place on the chart and that the epoch t is calculated for a given view of the six formulas numbered 1, 2, &c., without taking into account the change of Mars's position relatively to the earth. Then that view will be presented at the time $t-(4\text{ m. }6\frac{1}{4}\text{ s.})\alpha$.

The above data will be sufficient for determining the aspect of the planet at any time during the approaching opposition. Account will, of course, have to be taken of the gibbosity of Mars, as affecting the apparent position of his central meridian at any time; but the "Nautical Almanac" supplies the necessary information for this purpose.

The points to which I would direct the special attention of observers are three,—first, the position of the south polar snow-cap; secondly, the rotation-period of the planet; and thirdly, the determination of the configuration of various lands and seas presently to be mentioned.

If on every good observing night the angle of position of the centre of the snow-cap with reference to the centre of the disc could be determined in the same manner as in the case of a double star—the centre of the snow-cap corresponding to the companion and the centre of the disc to the primary—the observations could not fail to be of value, as showing whether the snow-cap occupies the true pole, or if not, how far from the true pole its centre lies, and also showing where the true south

pole of the planet lies. I do not here enter into the consideration of the method of calculating from the observed angle of position the true position of the axis, simply because the reader for whom the explanation would have any meaning will be able quite readily to obtain the required formulæ for himself. They are presented in an article of mine upon the opposition of Mars in 1873 in volume xxxiii. of the "Monthly Notices" of the Astronomical Society. But as there are some who find formulæ perplexing, especially when the manner in which such formulæ have been obtained is not indicated, I deem it desirable to indicate a construction by which the proper bearing and position



of Mars at any time can be easily and exactly indicated. It can easily be shown that this construction corresponds with the spherical formulæ given for such cases in the above-mentioned volume of the "Monthly Notices," and also in the explanation of Tables VII. and VIII. of my work entitled "Saturn and its System."

Describe a circle APB, and let POP', AOB be diameters at right angles to each other. From P measure on PB an arc PD

47° 56′ (the angle N of the formulas), and draw DΥ square to AB. From DA measure off the arc DAP′BF equal to the right ascension of Mars at the time considered. (I have taken the actual right ascension at the time of opposition on September 5, viz. 347° 19′; otherwise, for the general illustration of the method, I should have selected a more convenient arc.) From B measure off an arc on BPAP′ equal to the northerly declination of the planet:—the declination being southerly on Sept. 5—the extremity of this arc will fall on BP′ as at H, where BH is an arc of 12° 9½′. Draw the ordinates FM, HM intersecting in M, corresponding to the place of Mars on the star-sphere, where POP′ is the polar axis and AOB the projection of the celestial equator, Υ lying on the *concavity* of the sphere thus projected. Now take arc P*p* = 39° 42′, the inclination of the polar axis of Mars to the earth's polar axis (No. 1 of the formulas), and draw the diameter *pop′*. Then, if the point M be supposed brought to the centre O by two rotations, one round POP′, the other round AB, the position taken up by *pp′* will be the true projection of the polar axis of Mars at the time considered. The construction for this purpose is indicated by the dotted lines in the figure. (The full lines indicate constructions common to all cases; the broken lines indicate constructions for finding M; the heavy lines indicate final result, the broken heavy line being that part of the polar axis of Mars which lies between his centre and his unseen pole). Draw HK square to OP′, with centre K describe arc HL, meeting FM; draw *pk* square to OP, describe quadrant *plh* about *k*, take arc *hl* = HL (*i.e.* angle *hkl* = angle HKL); and draw lp_1 square to *pk*. Then p_1 is the position of *p* after first rotation. Next, drawing ap_1n square to OB, let p_1b square to *an* meet arc *ah′b* about *n* as centre in *b*; take arc *bh′* = BH; then $h'p_2$ square to *an* gives the place of *p* after second rotation. Thus $p_2op'_2$ is the position of the axis of Mars. It is readily seen that p_2 corresponds to the unseen pole, p'_2 to the visible pole. We must now take *oe* on op_2 equal to OK, then *e* is the place where the equator crosses the central meridian. The rest of the construction is the ordinary projection of a sphere. Half the equator is shown. It is a good plan, by the way, to complete the construction for one-half only on tracing paper, and to prick off the two halves in the final drawing from the same tracing, first from one side, then from the other. This secures symmetry with respect to the polar axis.

The construction above given occupies only a few minutes in practice, and gives results quite accurate enough for the correction of the position of Mars's polar axis. In fact it would be well indeed if the telescopic observers could obtain results even nearly as accurate as such constructions afford.

The determination of the rotation period, or rather, observation for correcting the rotation period, needs no special explanation. We have already seen how the time when the various features of the planet's surface will come to the central meridian can be determined beforehand. It is only necessary to note the actual time when they do come to the central meridian, to ascertain whether any correction is required. But in point of fact, observations made on the planet's rotation now, will only have any real value some century or two hence. The rotation period has been already calculated to within the tenth part of a second, for though Kaiser's result differs from mine by about that amount, I have shown that there are clerical errors in his calculation, (such, for example, as his taking the years 1700 and 1800 as leap-years,) and that when these are corrected the same rotation period within a 50th part of a second results from his researches as from my own, $24^h.\ 37^m.\ 22{\cdot}7^s$.

It remains only that I should consider what special observations of the features of Mars are now likely to be of service.

In the first place, I think the time has come for a more careful study of the varieties of light and shade and of colour in this interesting planet. It should be noticed that the apparent discrepancies between many excellent drawings are probably in the main due to this cause. I have studied hundreds of views of the planets, and at first I used to be greatly perplexed by finding that two skilful observers seem to see two different planets with their telescopes. The drawings constructed by one observer agree most satisfactorily *inter se*, and so do those obtained by the other; but when one set is compared with the other the most startling discrepancies are noted. I am disposed now to attribute this chiefly to the fact that slight varieties of shade have not been sufficiently noted, or, if so, have not been adequately indicated. In the main, observers are apt to divide the surface of Mars into two tints, one light, the other dark, and one observer will set a portion which is faintly shaded in the dark part of his picture, while the other not recognising the difference of shading, perhaps, or else considering it unimportant, sets that portion in the light part. As the colouring of Mars is in reality exceedingly delicate, especially in certain portions of the planet, and as, moreover, different eyes differ greatly in their estimate of colour, the drawings are not corrected on this account, as otherwise we should expect. The ordinary text-book notion that the surface of Mars is divided into a ruddy portion, a green portion, and the white polar snow-caps—with perhaps occasional white cloud-markings—is altogether remote from the truth. Only a very small portion of the land has a ruddy tint which can be regarded as well defined,

and though the greenish line of the seas perhaps extends a little more widely (at least for most eyes) it is wanting over large tracts usually regarded as marine in character.

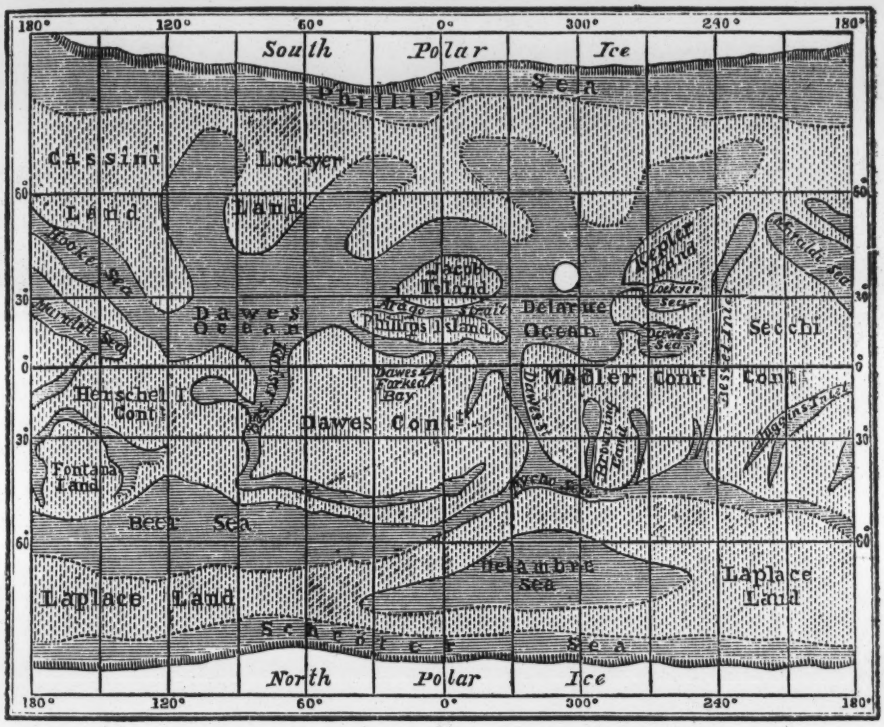


CHART OF MARS ON MERCATOR'S PROJECTION.

As a general rule it may be considered that a dark marking once fairly seen is to be regarded as indicating a sea-region, whether commonly seen or not. We cannot but suppose that on Mars as on our own earth, there are sea-regions where clouds are very prevalent, and where, therefore, we are seldom likely to catch the dark hues of the sea. Our observations are after all only made under favourable conditions at long intervals; and those of the northern regions of Mars have been as yet very imperfect, because when Mars turns his north polar regions earthwards, he is near the aphelion of his orbit, or, in other words, the summer of Mars' northern hemisphere, like the summer of our own northern hemisphere, occurs near the aphelion of the orbit.* This part of my chart of Mars will probably require more correction than any other part. In fact, from observations by Messrs. Green and Knobel (four of the latter I have given in the article Astronomy "Encycl. Brit.") it appears

* See Pl. xxvii. vol. ii. "Encycl. Brit.," (article *Astronomy*), which I have reduced from my chart of the orbits of the planets Mars, Earth, Venus and Mercury.

already that there is a large sea-region to the north of Dawes Strait, not shown in my chart. There is also a sea running southwards out of Nasmyth Inlet into Dawes Continent; and there are some reasons for believing that Nasmyth Inlet runs into Tycho Sea.

The following points have been indicated by Dr. Terby of Louvain, with regard to the regions just mentioned, as likely to need correction in my chart of Mars. In the main I agree with him.

1. As to the form of Tycho Sea and Delambre Sea. Is it probable, Dr. Terby asks, that those seas are as shown in my chart, or have they the extension indicated in the drawings of Knobel, Green, and others in 1871 and 1873? In other words, is Rosse Land a permanent isthmus, or was the light streak seen there by Dawes only owing to a passing cloud? I have already shown why I think the latter view the more probable.

2. What are the relations between the seas of Tycho and Nasmyth Inlet, Beer Sea, &c.?

3. The exact configuration of the two dark bands which connect the seas of Tycho and Delambre with regions further west, requires to be determined; may they not be simply the prolongations of those two seas, which in reality only meet on the eastern side?

4. What is the exact form of the faint prolongation of Tycho Sea towards the east, and what are its relations with Airy Sea.

5. To verify the solution of continuity between Tycho Sea and this faint prolongation.

6. To verify the existence of Lassell Sea and Leverrier Sea, of which no certain traces can be perceived in any drawings except those by Mr. Dawes.

7. To study the polar sea of Schröter.

8. To study the white region which Knobel and Green perceived immediately to the right of the Sea of Tycho.

He gives a similar series of questions relating to six principal line series of the planet's surface. I do not quote all his questions for want of space. The above series will indicate their general nature; the observer of Mars who notes with care the various and often varying features of the chief regions of the planet, should forward his pictures or tracings of them either to Dr. Terby, of Louvain, or to the Astronomical Society. It would be desirable to classify them in the way suggested by Dr. Terby, viz., with reference to the following six regions:—

1. Kaiser Sea and Dawes Ocean, with their chief dependent features, extending between 30° and 120° of areographic longitude in my chart. (In Marth's ephemeris published in the

April number of the 'Monthly Notices,' longitudes are measured from the first meridian eastwards, not westwards, as in Mädler's chart, which in this respect I followed.) The northerly limit of this region is in lat. 45°.

2. The region including J. Herschel Strait, Arago Strait, and Newton Strait, extending about 30° east and west of the first meridian, which passes through Dawes Forked Bay.

3. De la Rue Ocean with Dawes Sea and Lockyer Sea, extending as far east as Bessel Inlet. It extends between 240° and 330° longitude, and reaches to 30° north lat.

4. Hooke Sea and Maraldi Sea, with Huggins Inlet, Huyghens Sea and Bessel Inlet. Between 120° and 240° long. and reaching to 30° N. lat.

5. Tycho and Delambre Seas, and the northern part of Dawes Strait ("I have made a special study of this," says Dr. Terby, "as the least known of the Martial regions," for which reason I have given all his questions relating to this region.)

6. Beer, Airy, and Schröter Seas, Oudeman's Inlet, and their relations with Bessel Inlet and Huggins Inlet.

The two last regions complete the surface of the planet, extending from 30° north latitude to the northern pole.

Great interest will attach to the study of such changes as may be produced by the formation and dissipation of clouds over the surface of Mars, or the melting of snows either with the progress of the Martian year or possibly even during the course of the Martian day. The approaching opposition occurs about a fortnight before Martian midsummer for the southern hemisphere, the date of which is about September 18. As the melting of the snows which surround the southern hemisphere will probably reduce that snow-cap to a minimum about a month later, observers will have a very favourable opportunity of studying the reduction of the southern snows. Moreover, the smallness of the snow-cap will render it easier to ascertain whether its centre is coincident with the south pole, or, as is now generally believed, measurably displaced from that point. Observations directed to this end cannot but be regarded as extremely interesting. They will not only help to determine the true position of the Martian pole, but also to indicate the position of some of the midsummer isotherms for the southern hemisphere. According to the observations heretofore made, it would appear that the southern snow-cap reaches furthest from the pole in about longitude 30° east of the first meridian.

A few words may be added here respecting the nomenclature in my map. When I was constructing my chart of Mars, I proposed to write a treatise upon the planet. That was in

1867. A letter from the late Professor Phillips to Messrs. Longmans, dissuading them from taking the risk of such a work, and my inability at the time to incur the expense of it myself, caused me to give up the idea. Later a pressure of many other engagements has interfered with my intended resumption of the scheme. But it was the circumstance that I had such a work at that time in preparation,* which led me to add names to my chart of Mars; because in the accounts which I should have had to give of the various features of the planet, names would have been convenient if not absolutely necessary. The rule which I adopted in the selection of names was simply to assign to the chief features of the planet the names of observers who had detected such features; to features next in importance the names of observers who had extended, but not in equal degree, our knowledge of the planet's surface; and to minor features the names of those who had advanced our knowledge of the theory of the planet. This was done simply for convenience. Some principles had to be adopted, and the above seemed as good as any which occurred to me. There was no idea of recognition of the labours of the various observers or mathematicians in question. It has always seemed to me that such ideas are absurd, and almost childish. As the chart was almost entirely formed from drawings by Dawes (though I studied many others), and as he expressed a wish that his name might be given to certain minor features which he alone had observed, as Dawes Forked Bay, Dawes Snow Island, Dawes Strait (which last, however, has been seen, I have since found, by Lehardelay, Secchi, and others) his name appears several times in the chart. Other names appear more than once. This I now think a mistake, and propose to correct, taking counsel to that end with Dr. Terby, and others who have recently endeavoured independently to advance Areography.

But, in the meantime, M. Flammarion, who has not advanced our knowledge of Mars by observation or calculation, or has at least published no account of work to that end, has formed what he calls a new chart of the planet, which is, in point of fact, simply my own chart changed according to Dr. Terby's suggestions of what *may* have to be done in this way. In this new chart, the nomenclature is entirely altered. "The principle of 'recognition' or of 'homage' to the great men who &c. &c." is taken as the basis of the new nomenclature. Those who have enabled us by their observations to chart the planet are relegated to small bays and peninsulas, while to those who have advanced

* I hope to be able shortly to carry out that purpose, and probably the work will not suffer by the delay.

astronomy generally (who are far too numerous for the purpose) are assigned the oceans, seas, continents, and lands of the planet. The chart as a whole, thus modified, becomes M. Flammarion's chart! "La carte que je viens de tracer," he says, "est donc en realité un cinquième essai." Elle "représente exactement * l'état actuel de nos connaissances sur la géographie de ce monde voisin." In reply to Dr. Terby's somewhat energetic reclamation on his own behalf and mine, M. Flammarion coolly rejoins that Riccioli's nomenclature replaced that of Hevelius, and not improbably his will replace mine. This may or may not happen, and in itself it matters little which nomenclature is adopted, so that confusion be avoided. But the reference to Riccioli is a little unfortunate. The following passage in my "Moon" was written three years before M. Flammarion's new chart was formed, and certainly without any expectation that it would ever be useful to point a moral; M. Flammarion would hardly wish to have his new names adopted in the same way as Riccioli's, as thus described:—"Father Riccioli of Bologna published in 1651 a much less valuable chart than that of Hevelius. He adopted a new system of nomenclature, replacing the terrestrial names of Hevelius by the names of astronomers and philosophers. Mädler says, indeed, that Riccioli's work would have been forgotten, had he not been led by vanity to find a place for his own name on the moon—an arrangement only to be achieved by displacing all the names used by Hevelius, at the risk of causing perplexity and confusion to later astronomers. The charge is rather a serious one." Strangely enough M. Flammarion has in the most marked way left the most striking feature of Mars—the Kaiser Sea—with no other name than Mer du Sablier or Hour-Glass Sea. Whether the hint will be taken remains to be seen.

* Dr. Terby considers the corrected chart inferior in accuracy to mine, and after the study of a great number of views of the planet, I feel confidence in asserting that Dr. Terby's opinion is just. Some of the features as drawn by M. Flammarion are scarcely recognizable.

EXPLANATION OF PLATE VII.

Six stages of Martian rotation, separated by 60° or four hours of Martian time. In fig. 2, the first meridian of the chart passes about 30° east of the centre of the figure.

THE VOLCANOS OF THE HAUTE LOIRE AND THE ARDÊCHE.

By the Rev. W. S. SYMONDS, of Pendock.

[PLATE VIII.*]

So vast are the accumulations of volcanic materials of different ages in Auvergne which have burst out through the old granitic land that bordered the eocene and miocene lakes of the Limagne, that we are apt to ignore the granite masses which constituted the ancient country through which generally the volcanos of different ages burst. When, however, we visit the higher regions of the Forez, the Haute Loire, the Ardêche, and the Cevennes, we pay more attention to these mountain masses of crystalline rocks, they gain on our respect, and we wish to know something of the time of their elevation and their claim to antiquity. Mr. Scrope directed attention to the great frame of secondary rocks which surrounds the upheaved granite country. These secondary rocks include an extensive series of strata which are now known to be of Liassic, Oolitic, and Cretaceous ages. In some localities, as in the Cevennes, these limestone strata are tilted with the granite rocks, and attain to a very considerable elevation, while in others towards the north-west they decline with the granitic rocks. In the Ardêche, in the Coiron mountains, they occupy a wide and nearly horizontal table-land, and have been overflowed by basalt and protected from denudation. Here the upper beds are of lower Cretaceous age, and the question arises in the mind of the lover of physical geology, Did the Cretaceous and Jurassic seas once roll their waters over the country of the Auvergne, where now rise the heights of Monts Dôme, Mont Dore, the Cantal, the Forez, and the Haute Loire? or was this granite country an island even in those far distant epochs? I have directed attention, in my paper on the Auvergne country, to the occurrence of Eocene species of mammalia in freshwater beds, at Gannat and Le

* This plate, containing a sketch-map of the district, will be published with the concluding portion of the article.

Puy en Velay, and it is well to bear in mind that the elevation of some of the highest mountain ranges in the world has taken place since the Eocene epoch. We have picked up Eocene fossils at a height of nearly 10,000 feet on the Swiss Alps, and friends have sent us specimens from the height of 20,000 feet from the mountains of Thibet. In Europe, in Asia, in Africa, the stony relics of animals which once flourished in the deep waters of the Eocene seas are now elevated thousands of feet above the level of the plains. The very sites of great cities, such as London and Paris, are crowded with the fossil remains of animals which lived on Eocene lands, or frequented Eocene waters, and whose forms and shapes testify to the vast climatal changes which have happened in our latitudes since they lived and died. The mammalia of that epoch were so strange in form and structure that it is difficult to recognize in them any relation to existing species. The palæotheres, which frequented the shores of seas, estuaries, or lakes, where are now the Isle of Wight, London, Paris, and Auvergne, were types of the existing rhinoceres, tapir, and horse; and the Hyænodon which preyed upon them, and whose remains have been found in Hampshire and in Auvergne, was a carnivore which combined the destructive energies of the wolf, the hyæna, and the tiger. Then as regards the plants. The Eocene plants of these latitudes were of sub-tropical types and genera, and have almost altogether disappeared from lands whose climate is no longer adapted to the palm, the cinnamon, and the custard fruit. With them, too, have disappeared from the seas the turtle, the great sub-tropical shark, with numerous forms of sub-tropical shells; and the crocodile no longer haunts our lakes or rivers, as it did when the gypsum of Montmartre was accumulating where now is that Parisian hill.

It is impossible to visit the museums in Paris and see there the relics of mammalia, reptiles, and birds which have been found in Upper Eocene lacustrine beds, and the shells and other remains of marine animals which lived in the Lower Eocene seas, without feeling sure that Eocene lands as well as waters were teeming with life. Fifty extinct types of mammalia have been found in the Paris gypsum alone. And yet all we know of the land-life of the Eocene epoch may be said to be furnished by a set of quarries which in France and England together would not occupy a square mile of ground. No wonder Sir Charles Lyell insisted on the imperfection of the record. Now the Miocene strata of the Continent, so poorly represented in Great Britain, afford many more fossil remains of land animals attesting the existence of Continental areas inhabited by vast numbers of quadrupeds, which lived on the borders of ancient rivers, and whose remains are found in the silts of

ancient rivers and lakes. The hordes of the Persian tyrant when he burnt Athens could hardly have been more numerous than the swarms of animals, mastodons, dinotheres, hipparions, and giraffes, which frequented the Miocene plains, where now stands Athens, and where now rise the mountains of Greece. In France, Switzerland, and Germany are freshwater strata, the silts of ancient Miocene lakes, which all tell a similar history of the existence in European areas of widespreading Miocene lands.

There has always been a good deal of difficulty about the separation between the Miocene and Eocene formations. In the country around Paris, French geologists drew the line at the Fontainebleau sands, and placed the Montmartre gypsum and its mammalia as the summit of the Eocene series. The Montmartre beds belong to a *freshwater series*, and the Fontainebleau (Miocene) sands are marine, and full of a characteristic shell, namely, *Ostrea cyathula*. Sir Charles Lyell formerly objected to this division, but admitted it as the only one agreeing with the distribution of the Eocene and Miocene mammalia; which, after all, must be the most important test, as the mollusca are known to be so much longer lived as regards geological time. I mention these circumstances because marine shells of the Miocene age are said to have been found near Issoire and Le Puy en Velay; while the Eocene silts which contain Eocene mammalia both in Auvergne and at Le Puy en Velay are undoubtedly freshwater. The traveller may reach Le Puy en Velay by rail from Lyons by St. Etienne; but we advise the route by Issoire and Brioude from Clermont Ferrand. Issoire, the ancient Issiodorum or Issidore, was a place of considerable importance in Roman times and the residence of a prætor. The church is remarkable for its size, stateliness, and decoration in colours. It is a fine specimen of Romanesque architecture, from its circular eastern apse to its western front, which is, like our early Norman, quite plain, with billet moulding round the arches. Over the square front is a square tower, with two rows of round-headed windows, and in the centre is an octagonal tower, likewise showing two rows of windows besides a short spire. Within the church the great height and length are very imposing, and the date of the building is reputed to be A.D. 939.

I have alluded in my former paper to the geology of Issoire. It appears to me that there is still much to learn. The Puy Barnère is the highest elevation at which the tertiary freshwater strata are found in all Auvergne, and Mr. Scrope makes the height to be 2,730 feet above the sea. This hill should be visited in order to see the basalt resting at this height on dense masses of freshwater limestones and marls. But the most important researches in the Issoire district are those which would lead to a thorough investigation and correlation of the various

positions of the different alluviums, breccias, gravels, and drifts of the country, for nowhere do we find the excavation of valleys more marked by older and newer gravels, as well as by the position of older and newer lava sheets. Nowhere can we study better the masses of conglomeratic alluvia which descended the valleys, and are so largely developed at the Dent du Marais near Lac Chambon, at Necher and Champeix. Unfortunately when at Issoire I had little time to examine the physical position of these various alluvia and drifts, although I had notes of localities where certain species of mammalia have been found. Two kinds of marmot (*Spermophilus* and *Arctomys*), have been discovered in drifts or breccias near Issoire, at Paix, Coude, and Champeix, and with these were found the lagomys, or arctic tailless hare of Siberia, now no longer living in Europe, and remains of the mammoth. The caves of Champeix, too, have yielded the remains of bear (*Ursus spelæus*), badger (*Meles*), and horse. Hyæna also has been found in this district. With respect to the Pliocene mammalia, they have been found in great abundance in the tuffs and breccias of Mont Perrier, and with them are *Mastodon arvernensis*, *Elephas meridionalis*, *Rhinoceros etruscus*, *Hippopotamus major*, and the great tiger, *Machairodus cultridens*, most of which occur in the forest beds of Norfolk. Mr. Scrope informs us that the researches of MM. Croizet, Bravard, and Pomel indicate that the remains of mammalia from the bone beds of Mont Perrier belong to successive tertiary epochs, and that there are distinct assemblages of species preserved in the different bone breccias; in short, that there are Mont Perrier stratified tuffs and breccias of Miocene age containing Miocene animals, and Pliocene tuffs and breccias containing Pliocene quadrupeds. But this is not easy to understand, for it is evident that the old Miocene basalts, which now are found high up upon hills, had been excavated, and deep valleys cut through them into the freshwater strata, long before the lower bone-bearing gravel drifts and the Mont Perrier tuffs which overlie them had been deposited. It seems to me that the remains of the Miocene animals in the Mont Perrier tuffs were probably washed out of older strata, and were buried in the flows of mud which accompanied the later volcanic eruptions which burst out in Pliocene times. There are no phenomena in Auvergne so puzzling as these conglomerates and breccias. How masses of trachyte from Mont Dore and prisms of basalt, unworn, and with their angles uninjured, arrived at such positions, as the Puy de Monton, twenty miles from the Pic de Sancy, it is very difficult to say. In the neighbourhood of these mud breccias, too, it is well to be careful about attributing the transportation of rock masses to the action of a glacier, for in some instances the mud has been washed out and

the blocks left stranded. This may be seen in the neighbourhood of the Dent du Marais. Up the Allier from Issoire is Brassac. This Carboniferous outlier is separated by a great tract of elevated granitoid gneiss from the coalfield of St. Etienne miles away to the eastward on the right bank of the Loire. It lies in a hollow of granitoid gneiss, and is overlain on the west by the tertiary freshwater marls, which near Ardes to the westward are themselves overlain by basalt. Volcanic outbursts of comparatively late date, have penetrated through Carboniferous rocks, tertiary marls, and granite in this district, and are seen in masses of scoriæ and peperino. Le Vernet, famous for its amethysts, lies to the north-east of Brassac, and is situated on granitoid gneiss.

Brioude is not quite half-way between Issoire and Le Puy. It was once a Roman settlement, and in later centuries suffered from the ravages of many armies which from time to time desolated France, and from the proscriptions, wars, and massacres which accompanied the suppression of the Huguenots and their love of civil and religious freedom in Haute Auvergne. Brioude is now an old rambling town, quaint, odoriferous, and dirty, with houses which once saw better days, and apparently belonged to wealthier inhabitants. The site of the church is believed to have been occupied by a Roman temple, and the Christian forms of worship to have been established here in the old home of paganism. The portal is very fine, and the revolutions which time has wrought have not been able altogether to efface the ecclesiastical monument of bygone centuries. Here we have the southward prolongation of the tertiary freshwater strata of the Limagne and of the valley of the Allier, and here the granitic gneiss, through which the river flows so many miles from its source, abuts against the stream, and rises to the south in the Montagnes de la Margeride, and the mountains of the Haute Loire. In this elevated region rise, not only the Allier and the Loire which flow northwards, but the Ardêche, Erioux, and many streams which flow to the Rhone. At Vielle Brioude we cross the Allier by a fine bridge, but the river is subject to such violent floods that its bridge and railway are exposed to considerable danger. In 1824 the old bridge of Vielle Brioude fell wholesale into the Allier. A little west of the village of Vielle Brioude is the village of Sempole. This place and the ruined Castle of Massiac are built on outliers of a current of basalt which flowed from the great Etna-like volcano of the Cantal on the south-west. In fact, the stream divides the volcanic outbursts of the Cantal from those of Langeac and Le Puy.

In the fifth century, in the days of Clovis and Childebert, Brioude was considered a place of importance, and Auvergne a rich and tempting land. Gibbon says that "the sides of the hills were clothed with vines, and each eminence was crowned

with a villa or castle;" and relates, on the authority of Gregory of Tours, how Theodoric, the eldest son of Clovis, led his troops, reinforced by the fiercest barbarians of Germany, and spread desolation over the fruitful face of Auvergne. Two places only, a strong castle and a holy shrine, were saved or redeemed from their licentious fury. The fortress he fixes on was at a place called "Castel Merliac, two miles from Mauriac." At all events, the higher rocks and commanding situations appear to have everywhere been fortified at an early period, as the Puy Dallet near Clermont. On the occasion alluded to, the church of Brioude was sacked, and a division made of the spoils at a small distance from the town.

To the west of Brioude are the high granite summits of Le Forez near La Chaise Dieu, where rise numerous tributary streams both of the Allier and the Loire. This is a wild inhospitable district, with forests of fir still tenanted by wolves. Here, too, as in Cevennes, the Huguenots, when they became an isolated and proscribed race, often took shelter, during the Reign of Terror in the days of Louis XIV. The singular village of La Chaise Dieu was once famous for its Benedictine abbey, founded as early as 1452 by a canon of Brioude, who was afterwards looked upon as a saint, under the title of St. Robert. The once extensive monastery is now desolate enough, the great tower and some melancholy buildings attached to it being all that remains. The church is remarkable for its size, its fine windows, carved oak, and a fine tomb and figure of Clement VI. But where are the worshippers? All is mouldering and damp, and the country around is wild and drear, the granitic gneiss weathering into a poor unfertile soil, traversed by torrents, which in rainy weather turn the Loire and Allier into roaring floods.

Nevertheless, the geologist may in this district gather a good deal of information as to the physical conformation of the country long, long ago. He may roam among those granite heights and restore in imagination the features of the country, even as far back as Eocene times, before the mountains of Cantal, Mont Dore, or Monts Dôme, now such grand features in the landscape, had any existence. No doubt long ages of denudation have planed down the peaks and precipices of the old granitic mountains; but there stand "the eternal hills," their forms and features greatly changed perhaps, but looking down now from the most elevated heights upon towns and villages where once flowed the waters of fresh-water lakes. By the shores of the old lake of Le Puy the long extinct forms of the palæothere and anoplothere might have been seen roaming about; and the gazelle-like xiphodon was chased by the hyænodon over the granite mountains which rose above the lakes.

Then in later times (Miocene) those same mountains were the haunt of mastodons and rhinoceroses, the hipparion, and the stag; and the dinothere frequented the waters of Miocene lakes, which were in existence when the Cantal was vomiting forth its volcanic fires, and Mont Dore was sending forth streams of lava twenty miles in length.

On crossing the Allier from Vielle Brioude on our way to Le Puy, we pass over the base of the granitic rocks which rise into the mountains of La Chaise Dieu and Le Forez. Here and there deep wooded ravines diversify the scene, and at Paulhagnet we come upon recent volcanic masses which have burst through the granitic rocks, and which probably belong to the same age as the outbursts of the Puys de Dôme near Clermont. Near a place called Fix, the granite rocks appear again, and soon after we strike the volcanic eruptions of Mont Denise, and those around Le Puy. The most unimaginative sightseer can hardly look upon Le Puy en Velay without feeling a thrill when his eye rests for the first time upon that city with its Cathedral and its great pyramidal rock masses, the Rocher de Corneille and St. Michel. Le Puy is a strikingly picturesque town, with its lofty cathedral and two pyramids of rock, the one sadly defaced by a great coarse-looking statue in bronzed iron of the Virgin; the other surmounted by a strange old church. The town is built on the south side of Mont Anis in the form of an amphitheatre, and the Place de Meriel is a fine square with public buildings, while the streets are many of them narrow and odoriferous. The first impulse of the traveller is to make his way to one of the rock pyramids which he sees rising from the town; but which the narrowness of the streets and height of the houses hide from his view when exploring the streets themselves. The Cathedral stands below the Rocher de Corneille at the head of some steep streets. Portions of this venerable church are said to date from the eighth century, after the Saracens had been driven beyond the Pyrenees by Charles Martel (A.D. 732). The portico at the western entrance is grand. Flight after flight of stone steps must be ascended before we enter the lofty portal of noble vaulted arches, supported on pillars of Romanesque character. The doors under two side arches are carved with rude figures, said to be of great antiquity. The interior of the church is similar in character to the other early churches of Auvergne, with the exception of the vault, which is divided into two bays, each of which is domed. The interior of the building is degraded by a number of trashy pictures. We went near to the image of the Black Virgin of Le Puy, as no service was going on, and saw also a large painting of a procession of bishops, priests, and public functionaries, on the occasion of a jubilee. The literature on this subject

fills whole volumes. The image which now stands over the high altar is a new one, the original having been burnt in the Revolution of 1792, but we afterwards saw some curious relics of the original figure in the museum. These consist of the folds of papyrus which once enveloped the original Black Virgin. The sheets of papyrus bear Egyptian or Arabic inscriptions, and the figure itself was recorded to be of brown cedar wood, and with it was also said to be a conical stone bearing Arabic characters. M. Maudet, the historian of the civil wars of Le Velay, has given the most reliable information respecting this image and its history. Many have been the disputes as to the donor of the figure. The gift has been attributed to Dagobert, Charlemagne, and Philip Augustus, also to St. Louis. The general view now taken by the antiquarian is that the Black Virgin was originally an ancient eastern idol or image of Isis, of whose worship Le Puy, anciently Anis, the Aniscum of the Romans, was a great centre. It is not impossible that the Black Virgin was the object of worship before the days of the "Holy Martin," bishop of Tours, and his crusade against idols (A.D. 381).

St. Michel is a very picturesque rock rising to a height of nearly 300 feet, its diameter being only 400 feet. Steps cut in the solid rock lead to the church which crosses the summit; and near the base of the rock are the remains of a Roman temple to Diana, now in a sad state of neglect. The portal of the little church of St. Michel, on the summit of the rock, has a round arch enclosed within one of trifoliated design, and figures are carved about the doorway. On the west side is a semicircular choir, supported by Romanesque pillars, low, and carved in bas-relief.

The Church of St. Laurent at the northern entrance to Le Puy has only one object worth mentioning. This is the fine tomb of the noble constable of France, Bertrand de Guesclin. The celebrated soldier reclines at full length in armour of plate without his helmet. On his shield he bears a double-headed eagle. He is styled "Messire Bertram dankin." This tomb takes us back to the days of our own "Black Prince" and "Pedro the Cruel," and was erected to perpetuate the memory of "the most valiant knight, the most expert leader, the most fortunate and successful warrior who fought under the banner of France."

Before examining the country around we recommend a visit to the Museum of Le Puy, which is a large and handsome building. There are many objects of interest in the collection of Gallo-Roman relics from buildings, hypocausts, and tombs, and especially we noted a set of instruments of a Roman or Gallo-Roman oculist—scalpels of different form, forceps, tweezers, &c.—all finished with great care, and showing that even in those

times ophthalmic surgery had made considerable progress. The geological and mineralogical collection occupies a separate compartment, and should be studied before examining the geology of the surrounding district. In this communication we can only direct attention to some of the most remarkable mammalian fossils, and to the localities from whence they came, which we learnt either from labels attached to them or from the curator. From the drifts of Denise and near Polignac have been obtained bones and teeth of the mammoth and *Elephas primigenius*; from volcanic breccias near Solignac are remains of *Elephas meridionalis* and two species of *Rhinoceros* (*R. leptorhinus* and *megarhinus*, with bones and horns of a great stag. From Vialette we find *Mastodon Ronzoni*, *Rhinoceros etruscus*, and *Tapirus arvernensis*. From Ronzon we find *Cynodon velaunus* (with huge carnivorous teeth) and *Bothriodon*. From the marls and clays of Mont Anis and Corneille are the Eocene forms of two Palæotheres. These specimens are in the galleries. The strata which yielded the Eocene relics also yielded the eggs of water birds, the remains of reptilia, with some freshwater shells, such as *Lymnea* and *Paludina*, and the valves of *Cypris*. M. Aymard, in a paper read by him before the Scientific Congress of France at Le Puy, in 1855, fully recognized the lowest tertiary marls and clays of the basin of Le Puy to be of Eocene age, and he has also endeavoured to establish a triple division of the tertiary strata, viz., Eocene, Miocene, and Pliocene, as well as Postpliocene breccias, and his views are most important from his acquaintance with all the localities in which the bones were found. It is to be regretted that a better arrangement is not adopted in the museum, for different groups of bones have evidently got intermixed, and many of the best specimens are without names or the localities where they were discovered. With regard to the celebrated fossil human bones of Denise, we were disappointed. In the first place, the bones looked too fresh. In the second place, they are described as occurring in "a block of breccia," whereas they occur in a laminated sandy mass, with a mixture of lime. I have especially directed attention, in "Nature" (January 13, 1876), to an "iliac" bone in the museum. It rests between stalagmitic layers, as if the bone had been washed into a fissure through which percolated water, charged with lime. I shall endeavour now to direct attention to points which the geologist should visit in succession if he would become acquainted with the geology of the district.

Having seen the remains of glacial and northern animals in the museum, and learned that my friends Sir Wm. Guise and Mr. Lucy had, on a former visit, detected drifts with angular fragments near Polignac, which might be the beds indicated by

Mr. Scrope as containing bones of these animals, one of our first visits was to Polignac and Mont Denise. The rock of Polignac is one of those strange pyramidal rocks of basaltic breccia similar to the Rochers de Corneille and St. Michel at Le Puy. The Castle, of which little remains save the great tower and donjon keep, was once an important feudal stronghold, the abode of a race of tyrants who were the terror of the surrounding country. It was built upon a Roman site, for in the museum at Le Puy are many Roman relics which were found among its mouldering walls. The site is now overgrown with low shrubs, grass, and wild flowers, among which there still lies a slab of stone with a Roman inscription of the time of Tiberius, and a large bearded head which appears to be that of Jupiter, the mouth of which has evidently been used as a spout. South of the castle, at a short distance to the right of the road, near a place marked by a cross, is a ridge of consolidated drift, regularly stratified, containing lumps of granite, some as large as cannon balls, with fragments of lava. Two visits which we afterwards made over and around Mont Denise convinced me that this conglomerate is a diluvium made up of rock fragments washed down from above, and that it occupies at Denise fissures and hollows which are the localities, in all probability, from which the teeth and bones of the mammoth were obtained. The granite, before it was drifted, was, I do not doubt, blown out by volcanic explosions, as fragments are found on the surface of Mont Denise.

I think it necessary to separate these aqueous drifts and stratified conglomerates with mammoth remains from the volcanic muds and breccias. They look much more like those drifts which are the result of melting snows and running water, and it is important to remark them whenever they occur, as belonging to the period we term glacial. They not only occur in valleys, as below Polignac, but are heaped against the sides of the hill of Denise, above Polignac, and Captain Price and I found them beyond "the Chimney," on the road to Brioude, high up on the western flank of Mont Denise, and again on the north-east flank of the hill near the peperino quarries. L'Hermitage is the name of a little hostel below Mont Denise, on the road from Le Puy to Brioude, and it was near this place that the human skull and other bones in the Museum of Le Puy were said to have been found in a block of breccia. As I have already hinted, we never liked the look of these human bones, and since investigating the site whence, as we were told, they came, we liked them less than ever. We were conducted by the man who declares he found them when digging a well near the little auberge where he now resides, and he showed us the spot above the well, now built over by a wall, where the

remains of the skeleton lay. The locality given by Mr. Scrope in his sketch appears to be higher up the hill. Sir C. Lyell was also conducted to a place "not far from the summit of the volcano," but the well of the Hermitage is a long way from the summit of Mont Denise. We went from the museum to Denise, and again from Denise to the museum, on two separate occasions, and I convinced my companions as well as myself that the human bones were never enveloped in breccia, nor was the matrix of the mass in which they lie in the least like the breccia of the well of the Hermitage. I have already mentioned that some of the bones lie in a matrix which looks as if it was derived from a wash of volcanic materials, intermingled with lime, forming a kind of stalagmite; and as I dislike throwing entire discredit upon the word of the peasant who found them, I would suggest for future explorers the examination of the site for some distance above the well. It is not improbable that these human bones were washed into a crack or fissure, through which the water percolates downwards to the well of the Hermitage. The geology of Mont Denise beyond the "Croix de Paille" is of high interest. "The Chimney" section shows the older breccias, or stratified volcanic mud (peperino), blown away, and a great vent filled with red and black cinders. This last explosion of Denise was not apparently attended by any outflows of lava, but by violent discharges of volcanic cinders, dust, and bombs. The vent is well marked, the stratified older peperino presenting a wall-like line where the beds in the vent were blown away by explosive forces from below. While examining this remarkable section in detail we were struck by some yellowish-looking beds, which are seen resting in a hollow a little to the west of "the Chimney." These are, I believe, alluvial breccias or drifts of the same age and character as those near Polignac, and on the north-east flank of Denise. Another point also struck us, viz., that the explosions through "the Chimney" appear to be of later date than those drifts, for the black and red cinders are seen to overlie them higher up the hill.

(*To be continued.*)

NOTES ON THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS.

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THE study of the geographical distribution of living and extinct organisms has recently become one of the most important branches of philosophical natural history, from the light which it throws both on the former condition of the earth, and on the greatest scientific question of the day, namely, that of the origin of species. The geographical distribution of animals has lately received much attention, the most important contribution to the subject being a large work by Mr. A. R. Wallace; but in the present paper we propose to bring together such observations as may prove interesting, either from their importance or from their having been less fully discussed elsewhere.

Most naturalists are now agreed in recognising six main regions of geographical distribution, as originally proposed by Dr. Sclater, viz. the Palæarctic, Ethiopian (or African), Indian (or Oriental), Australian, Neotropical (or tropical American), and Nearctic (or North American) regions. The Palæarctic region includes Europe, North Africa, the northern half of Arabia, and the whole of Western and Northern Asia, as far as the Indus and Himalayas, and a line drawn eastwards, running south of Thibet and Mongolia, and somewhat north of Formosa. The Indian region includes, besides South Asia, the large islands of Borneo, Java, Sumatra, and the Philippines; but the islands further to the east belong to the Australian region. The Neotropical region includes the West Indies, Central and South America, and the south of Mexico; the remaining regions require no further explanation.

Although these regions are generally recognised as natural, we must not consider the divisions between them as hard and fast lines, except that between the Indian and Australian regions, where the island of Celebes is almost the only de-

batable ground. Indeed, the fauna of much of the west coast of America, especially that of California and Chili, exhibits such marked affinities with that of the Palæarctic region, that these countries have been regarded by some writers rather as outlying districts of the latter than as biological portions of the continents to which they actually belong. It is also to be observed that this division of the world into six main regions is more applicable to some groups of animals and plants than to others. Various attempts have been made to subdivide the regions, but though some subdivisions, such as the Mediterranean subregion, are eminently natural, our knowledge of the natural productions of most of the regions is not yet sufficiently exact to allow of their being divided in such a manner as to gain the general assent of naturalists.

Owing to the much greater competition of rival forms in large continents, the larger and more highly developed forms always appear to have originated and been brought to relative perfection on the greatest continuous districts of land. But notwithstanding the frequent alterations of level during geological ages, which have constantly united or separated various portions of the earth's surface, yet it appears that the largest masses of land, though differing in outline and continuity, have always occupied nearly the same places; that is, it is more probable that the contour of former continents has been changed by gradual increase or diminution, than that a whole continent should be submerged or elevated *de novo*. It also appears that the northern hemisphere, and more especially the Palæarctic region, has been the birthplace of most of the principal groups of animals, including those now confined to tropical Africa, or even to South America.* Nor need this surprise us, poor as is the present Palæarctic region, when we consider the great vicissitudes to which this region has been more especially exposed, and the many conditions unfavourable to animal life which it now presents. There is little doubt that the amazingly rich fauna possessed by Europe previous to the glacial epoch was then almost entirely swept out of it, a very large proportion of its original fauna and flora being either wholly exterminated or driven into distant regions, whence, on the abatement of the cold, their descendants would return very slowly, if at all. Besides, it is urged by Mr. Belt that during the glacial period such vast masses of water were locked up in snow and ice that the average level of the sea

* This is confirmed even by groups of which very few fossil remains exist. Mr. S. H. Scudder, in his recent work on fossil butterflies, only admits nine species, all European; but of these four are preponderatingly American in their affinities, three Oriental, one Mediterranean, and one African.

would be at least 1,000 feet lower than at present, and probably far more. This would lay bare great tracts of land possessing a much warmer climate than any other portion of the globe at that time, where many tropical forms may have survived the glacial period, though some would doubtless have been subsequently exterminated by the great floods which Mr. Belt argues would have occurred towards its close, from the melting of the ice. This view receives considerable support from the numerous traditions of submerged countries in the Atlantic, and off the coasts of China, India, Ceylon, and East Africa.

Great changes have recently taken place in the inland seas of the Palæarctic region. It was formerly bounded to the south by a great inland sea, resembling the Mediterranean, occupying the place of the Sahara; and a chain of inland lakes appears to have extended from Spain to the Black Sea. Wallace believes the Mediterranean to have then consisted of two great lakes, while North Africa was connected with Spain and Italy by extensive tracts of land now submerged. At this time, too, much of Northern Asia may have been depressed below the sea, or, at any rate, the great lakes, such as the Caspian, Aral, and Baikal, appear to have communicated with the Arctic Ocean. But there is still much obscurity relating to the geological history of Northern Asia; and until increased facilities of communication and changes in politics render China and Asiatic Russia more accessible to scientific men, it cannot be entirely cleared up. It is so difficult to account for the total disappearance of such forms as the mammoth from a country like Siberia, that some have suggested that they were destroyed by floods, to which indeed a great part of Central and Northern Asia was very probably subject, considering the much greater number and extent of the inland seas in former times, even if a large portion of the country was not actually covered by the Arctic Ocean. Much valuable geological information relating to Northern Asia in recent times must be still locked up in Chinese annals; and I have not yet met with any history by a competent geologist of the series of great volcanic disturbances, inclusive of earthquakes and floods, which devastated China during the first half of the fourteenth century, and which were felt with great severity at least as far as Austria and Greenland, and indirectly over the whole of the then known world, and there is reason to believe even in America. A history of these extraordinary phenomena, which are unparalleled in modern times for their extent and severity, if collected from the numerous available materials, and worked up by a competent hand, would be of the greatest scientific value.*

* The most accessible account of this period is perhaps that in Hecker's History of the Black Death, in his "Epidemics of the Middle Ages."

And here I may remark that I am convinced that great light would probably be thrown on the former state of the world in historic times by the study of Oriental literature by scientific men. There has been much discussion among Orientalists about the identification of the islands of Wák-wák, mentioned by Arab geographers, as well as in the "Arabian Nights." These are the islands, seven years' journey from Baghdád, where the trees bear fruit in the shape of female heads, suspended by the hair, which cry out, "Wák-wák" at sunrise and sunset. Then, to connect these islands more distinctly with birds, they are inhabited by jinneeyehs, who fly about in feather-dresses, which are sometimes stolen by some enterprising hero. Wallace describes the great bird of Paradise (*Paradisea apoda*) as being very abundant in the Aru Islands, and settling on the trees in flocks at sunrise, uttering a loud and shrill note audible at a great distance, which sounds like "wawk-wawk-wawk-wŏk-wŏk-wŏk." Anyone who will consult Lane's "Arabian Nights," vol. iii. chap. 25, note 32, and Wallace's account of the Great Bird of Paradise, in his "Malay Archipelago," chap. 38, will, I think, be convinced, like myself, of the identity of the Aru Islands with the islands of Wák-wák of the Arabian writers.* But even when animals are spoken of under their proper names, it will often be no easy matter to identify them in a translation; for I have generally found that the English, French, and German equivalents for the vernacular names of common animals or plants are rarely to be ascertained with any accuracy from the best existing dictionaries; and this difficulty would be greatly increased in the case of Oriental or ancient writings, in which animals, perhaps now extinct, would frequently be described in very hyperbolical language.

To return from this digression to Europe, we need not wonder that its present fauna is so much poorer than in post-glacial times, or even than a few centuries ago. The advance of cultivation, the felling of forests, and the draining of marshes have exterminated many species, even in our own day, while others have been destroyed as noxious creatures, as the wolf in Britain, and the lion in Germany† and Greece. Others were exterminated for food, as the great auk in the northern regions; and the urus and aurochs, both now almost extinct, the former only existing as *Bos scoticus*, and the other in Lithuania and the Caucasus, the last being the only locality where it is still actually wild. As, however, these wild cattle

* I am not aware that the reputed occurrence of this bird in New Guinea has been confirmed; and the islands of Wák-wák are always spoken of in the plural.

† Which it is believed to have inhabited during the heroic age.

are fierce and dangerous animals, they may have been exterminated partly for this reason. A very interesting volume could be written on the animals which have disappeared from Europe within historic times. When the ancient world was overrun by huge and destructive animals, it must have been difficult for men to make any progress in civilization; but when the glacial epoch had swept all before it, it was much easier for men to improve their condition. So far as we know, the ancient centres of civilization, such as Central Asia and Egypt, were less overrun with wild beasts than others.

The islands of Corsica and Sardinia, though barely alluded to by Wallace, are interesting from the number of peculiar species which they already contain, and for the still larger number of local forms, which, if isolated for a sufficient time, will ultimately become perfectly distinct species. Their fauna appears to have been derived from the mainland of Italy at a period when that country was already fully stocked with its present fauna, as they possess a large proportion of the Italian species. They have apparently been separated from the mainland for a much longer period than Britain from France; for, although Guénée calls Britain "le pays des variétés," well-marked species have not yet had time to develop themselves. Here, however, other considerations step in. The much hotter and finer climate of Corsica and Sardinia may have stimulated the more rapid differentiation of species. And although we are still ignorant of many of the laws which govern the range of species, yet it appears from the large proportion of species common on the French coast, and not extending to Britain, that Britain was separated from France before France had fully acquired its present fauna and flora. The same reasoning will apply to Ireland, which is much poorer in species than Britain.

Some writers think that the Glacial Period has not wholly passed away, and that the earth has not yet recovered its normal temperature; and although it would require a long series of observations, extending over many years, if not centuries, to arrive at absolute certainty, yet there are some historical grounds for believing that the climate of all Europe was much more severe only 2,000 years ago than at present.* How far the clearing of forests, &c., may have influenced the climate we do not yet know, nor whether its gradual improvement is due to local or general causes. It is quite possible that the animals and plants now confined to Eastern, Southern, or Central Europe are still extending their range north and west, so far as they meet with no barriers to their further migrations.

* Compare Mallet's "Northern Antiquities," pp. 242, 243.

In the case of the British Islands, there are other conditions besides breaks of geographical continuity which hinder the spread of some species. The unfavourable climate of the northern and western portions is probably one cause of the restricted range of many species, and their total absence from Scotland, Ireland, and in many cases, even from the north or west of England. Nothing strikes a naturalist, accustomed to the comparative abundance of insect life, even in the south of England, than its usual scantiness in Ireland, although the latter country probably possesses about two-thirds of our English species.

The Mediterranean subregion presents us with several interesting problems, in addition to some previously mentioned. During the time that Spain and Italy have been separated from North Africa, great changes have occurred in the insects of the opposite coasts, as well as in the larger animals which now inhabit those countries. Oberthur, in his recently published work on the Lepidoptera of Algeria, doubts if any Algerian species of *Zygæna* is identical with any European species. This, however, might perhaps be expected, for the genus *Zygæna* consists of a great number of closely allied and highly variable species which have their head-quarters in the Mediterranean subregion; and while some groups of animals (as many Mollusca) may remain almost unchanged for entire geological periods, yet others, which, like the species of *Zygæna*, are specifically unstable, may become modified very rapidly. But, notwithstanding the large amount of specialty in the Algerian insect-fauna, it is essentially the same as the European, and the African element is exceedingly small. (There are some species of insects confined to South Spain and South Russia. These are probably very ancient forms, and may even be relics of the preglacial Palæarctic insect-fauna.) The large mammals of Algeria are apparently nearly all of African origin, having crossed from the south after the Glacial Epoch, and subsequently to the disappearance of the Saharan sea, and to the final separation of Europe and Africa, although some identical species of wide range penetrated into, or perhaps returned to Europe through Asia Minor, such, for instance, as the lion.

The Ethiopian Region, or Africa, is at the present day chiefly remarkable for the great number of large mammalia which inhabit it. Many of these, though formerly abundant in Europe and India, have long disappeared from both countries; and Africa has now a highly specialized character of its own. The Malagasy subregion, including Madagascar and the adjacent islands, is peculiarly remarkable, and "appears to indicate a very ancient connection with the southern portion of Africa, before the apes, ungulates, and felines had entered it"

(Wallace, "Geogr. Distr." i. p. 273). The insects of Madagascar, however, are closely allied to existing African species, and many of the most remarkable, formerly supposed to be peculiar to the island, have since been received from Natal or Zanzibar. There is also a considerable resemblance between the Mascarene fauna, and that of distant parts of the world, in which connection we may refer to the numerous traditions, previously mentioned, of recent subsidences in various parts of the Indian Ocean.

As a rule, competition is far more severe on continents than on islands; hence the great number of peculiar forms which survive in islands, though long superseded on continents, and it appears that according to this principle, the insects of Madagascar have become less strongly modified than those of the African Continent, and therefore represent to some extent a more ancient fauna. A remarkable case is afforded by two pairs of butterflies, inhabiting different parts of the world. One is *Papilis Merope*, a large black and white butterfly, with tails on the hind wings, found all over Tropical Africa, and varying considerably in different localities. The females are altogether unlike the male, being without a tail, and of a totally different shape and colour, resembling butterflies of other groups, which are protected from birds, &c., by their nauseous odour. But *P. Merope* is represented in Madagascar by *P. Meriones*, the female of which only differs from the male in the presence of an additional black bar on the fore wings. The other example is that of *Argynnis Niphe*, a common Indian species, which is tawny, with black spots, and the female of which has the tips of the forewings broadly dusky, with a black bar across them, giving it a great resemblance to *Danaus Chrysippus*, a widely distributed insect, which is "mimicked" in the same way by the females of several other butterflies besides *A. Niphe*, even including one of the female varieties of *Papilio Merope*, already referred to. But the Australian representative of *A. Niphe* (*A. inconstans*), though differing so little from the male of *A. Niphe* that it was long considered to be no more than a slight local variety, has the sexes alike, the female having no white bar on the wings, although a small *Danaus* (*D. Petilia*), closely allied to *D. Chrysippus*, is also found in Australia.

Turning to the Oriental Region, we find that North India is much richer in species than the south. This is partly owing to the greater variety of elevation (just as the southern peninsulas of Europe are poorer in species than the districts in which the central ranges lie*), but not entirely, since many North Indian

* Andalusia scarcely produces more species of butterflies than Sweden; Austria, Switzerland, or South France have nearly twice as many.

species, not found in South India, reappear in the Malayan peninsula and islands. The spread of Indian forms into Europe has been much checked by the position of the mountain ranges. Where these are more open, as along the coast of China and Japan, we find Indian forms extending much further north, and mingling with those which really belong to the Palæarctic Region.

One of the most striking features in the Australian Region in recent times was the abundance of large wingless birds, now mostly extinct. Traditions, more or less authentic, relating to the great birds of the remote islands, are common in Oriental writers, who referred to them under the names of Rukh, Seemurgh, Anka, &c. The rukh was said by Middle Age writers to be found in Madagascar (doubtless referring to the *Æpyornis* or its egg); but the Arabian writers always give the rukh the habits of an eagle or a vulture. The Arabs, we know, extended their voyages at least as far as Madagascar and the Aru Islands, and there is no improbability in their having also visited New Zealand, where I believe that remains of a gigantic bird of prey have recently been met with. The Arabs, of course, were well acquainted with the ostrich, now the largest living bird; hence, nothing but the great extinct birds could have given rise to the stories of the rukh. The Persians, less acquainted with these distant countries than the Arabs, made a mythological bird of the Seemurgh, but there is little incredible in the Arabian accounts of the rukh, except its gigantic size. The Greek or German Griffin may have had a similar origin.*

The Neotropical Region presents a great contrast to Africa, the other southern continent, for instead of a preponderance of large mammalia, we have here an enormous abundance of some of the smaller forms of life; in some groups, as, for instance butterflies, more than half of all the known species come from Tropical America.

The Nearctic Region, though somewhat poor in special forms as compared with the Palæarctic, to which its affinities are so close that it could scarcely be separated as a distinct region, if we confined ourselves to isolated groups, yet possesses as many large mammalia as South America. The fauna of both North and South America was formerly much richer than at present; but the Glacial Period was as destructive in North America as in Europe. What caused the destruction of the large mammalia

* The Rukh, or Roc, as in our old translation of the "Arabian Nights," is only alluded to, so far as we remember, in connection with its egg; the egg was probably that of *Æpyornis*, and the bird manufactured to suit it.—Ed.

in South America is less certainly known; but Africa is now the only region which is sufficiently rich in the higher forms of life to lead us to suppose that it in any degree adequately represents the zoology of former times; and it appears to have been exposed in a less degree than other countries to the agencies which have destroyed animal life to so great an extent elsewhere.

In concluding this somewhat desultory article, we may remark that, contrary to the general idea, extreme heat seems to have a tendency to reduce the size of animals. The largest known animals are, or were, natives of cold countries; and most insects common to Europe or Japan, and India, are considerably smaller in the latter country. Even the tropical representatives of widely distributed genera are nearly always inferior in size and beauty to temperate forms.

ON ICE-MAKING AND ICE-MACHINES.

By W. N. HARTLEY, F.R.S.E.

THE resolution of all forms of energy into heat, the continual passage of heat through solids, liquids, and gases, and its tendency to become equally distributed through all matter, are now recognized as facts; hence the inevitable conclusion that finally all substances in the solar system, if not in the universe, will ultimately arrive at one common temperature. Mechanical motion, electricity, chemical action, all other forms of energy which at present are sources of heat, will be completely exhausted. Man, by his use of machines, is hastening this end of all things, and this indeed by the production of low as well as of high temperatures.

An economical means of freezing water is a fruitful source of profit at the present time, for the manufacture of ice serves not only the purpose of enhancing our bodily comfort in summer, but also for rapidly cooling large volumes of liquid, as in the operation of brewing and other industrial processes, and for the better preservation of animal food in seasons and climates which hasten putrefactive changes.

The difficulty experienced in freezing water is due to the very large amount of heat it must lose, firstly, in being lowered to the temperature of 32° F., and secondly in being changed from liquid water at 32° F. to solid ice at the same temperature. The first quantity is called its specific heat, and the second is its latent heat. These quantities are greater for water than for any other substance, hence the cooling power of ice is greater for any given temperature than that of any other body, and the cooling power of water is greater than that of any gas or liquid. Faraday calculated that the heat absorbed during the conversion of a cube of solid ice measuring three feet in the length of one side, into liquid water without undergoing any rise of temperature, would require the combustion of a bushel of coals for its artificial production.

It is evident from these statements that, in order to cool a

quantity of heated air or water down to a moderate temperature, a large supply of water is the best medium, not only on account of its abundance and cheapness, but because of its great capacity for heat.

When any elastic fluid is compressed, it becomes hot, and if it then be cooled down to its original temperature and be expanded, it is rendered as many degrees colder by its rarefaction as it was heated by its condensation; hence we have here a means of producing low temperatures. On the one hand we can ignite tinder by the heat evolved in the compression of air in a glass cylinder; and by the exhaustion of air in a bell jar the temperature may be reduced so that the moisture it contains is deposited as a mist. By the extremely rapid expansion of a liquefied gas when pressure is removed, or of a volatile liquid when its evaporation is hastened by mechanical means, we obtain the most effective cooling powers. The familiar experiment of freezing water or mercury in a red-hot dish is effected by the enormous expansion of liquefied sulphurous acid or of solidified carbonic acid, which substances regain the heat they lost when undergoing the change of liquefaction or solidification.

The production of intense cold by the rapid evaporation of ether projected in the form of a fine spray is a process which has been introduced with success into surgery by Dr. Richardson, for the purpose of producing a local insensibility to the pain caused by a knife or other instrument.

By enclosing ether in an air-tight vessel, and drawing off the vapour as fast as it is generated, evaporation is greatly accelerated, while the ether may be condensed again for further use. The original apparatus of Harrison, which depended upon this principle, consisted of a multitubular boiler immersed in an uncongealable liquid such as brine; an exhaust pump carried off the ether vapour which is rapidly formed at the expense of the warmth of the salt water. The reduction of temperature may reach 24° F., or what is commonly called 8° of frost. The ether was condensed by passing through a worm tube surrounded by a stream of cold water, and the chilled brine was made to circulate round metallic vessels containing the water to be converted into ice.

Many improvements have been made on this ether machine, and one of the most complete methods of working is now in operation on a large scale on the premises of the Manchester Patent Ice Company.

Messrs. Sidely and Mackay, of Liverpool, are the patentees of the apparatus, the chief characteristics of which are its adaptability to the satisfying of large demands, its economical use of the cooling power of the ether vapour, and its capability of making ice in thick blocks. Not only are exhaust pumps used

for evaporating the ether in the refrigerator, but pressure is exerted to liquefy the ether in the condenser. Both refrigerator and condenser are tubular vessels. Now, as the vapour passes from the refrigerator to be condensed by the pump, it is made to part with some of its chilliness either to ether going to the refrigerator, or to water about to be frozen; and again in its return passage to the refrigerator it is deprived of any oil which it may have acquired from the machinery. The whole of the cooling apparatus is below ground, and contained for the most part in pits of cement or asphalte. The water to be frozen is run into metallic tanks, between the inner and outer surfaces of which chilled brine at a temperature of 15° F., or 17° below freezing point, is made to circulate, the metallic vessels being connected by stout vulcanized india-rubber tubing. The water during freezing is kept in constant agitation, with two objects—first, to remove air, and so obtain clear ice; and second, to equalize the temperature throughout, so as to prevent the water freezing on the surface, as it ordinarily does on a pond. The ice is formed first round the sides of the cell, and gradually thickens till it closes up in the centre. The clearness of the ice is greatly increased by slow freezing, and to obtain this desirable condition the time allowed is from 60 to 90 hours. Each block of ice measures 3½ feet broad by 4 feet long, and is 13 inches in thickness; the weight varies from six to seven hundredweight. A simple contrivance to facilitate the removal of the ice by a crane travelling on rails laid on beams overhead, is a loop of rope which is frozen into each block. The ease with which, when placed on the ground, these large blocks can be slid about by the men is very advantageous. In order to loosen the ice from the cells, brine at any temperature above 32° F. is made to circulate in place of the frigorific liquid, and so greatly are the metallic vessels cooled that it requires a period of about an hour to loosen one of the blocks.

The magnitude of the operations is such that the engines can be worked up to 100-horse power, and are capable of turning out 30 tons of ice per day. On the occasion of a recent visit to this interesting factory there were 180 tons of ice in store, and some of the blocks were five weeks old. We have an apparent paradox in the fact that the combustion of one ton of coal in the furnace fires will produce eight tons of ice.

In the last number * of the POPULAR SCIENCE REVIEW it was found necessary to refer to the researches of Faraday and others on the liquefaction of gases, and of Professor Andrews on the continuity of the liquid and gaseous states of matter; it is therefore of great interest to note how a purely scientific fact

* See "Mineral Cavities and their Contents."

can in a most unexpected way be made available for industrial purposes. No one could have imagined that the liquefaction of gases could prove of any practical benefit to mankind, but we now know that such is the case, since M. Carré's ammonia freezing machine depends upon the liquefaction of the gas by pressure, and its subsequent condensation in water after it has produced a low temperature by its evaporation. The operation is conducted without the application of any mechanical power. A hollow conical condenser of iron has a space between its inner and outer surfaces, which is connected by a tube with a boiler containing ordinary liquid ammonia; that is to say, a solution of about 700 volumes of ammoniacal gas in 1 volume of water. The conical condenser is immersed in a stream of cold water, while the boiler is heated over a fire or large gas-burner to a temperature of 270° F. During this operation the ammoniacal gas is expelled from the water, and is condensed by the pressure of its own particles and the cooling action of the stream of water. If now fresh cold water be placed in the condenser cone, and the heated boiler be cooled in water, the ammonia distils off at the expense of the heat in the water to be frozen, and finds its way back once more to the boiler, ready for another operation.

Leslie's famous experiment of causing water to be frozen by the rapid absorption of heat caused by its own evaporation has been modified by M. Carré, in such a manner that ice in small quantities, as, for instance, in water-bottles, may be made in a few minutes. The apparatus consists of an air-pump, to which the water-bottle is attached. As the handle of the pump is worked and the air exhausted, a quantity of oil of vitriol is agitated in a vessel, through which all aqueous vapour and air from the water-bottle must be drawn. The avidity with which the oil of vitriol absorbs the vapour as fast as it is formed so hastens the evaporation that in a few minutes a bottle of ice is the result.

Perhaps of all machines the one of most interest is that invented by M. Raoul Pictet, of Geneva, the striking feature in which is the employment of liquefied sulphurous acid as the absorbent of heat instead of ether. In all other machines there is a liability to a slight leakage, on account of the fact that the cylinder of the exhausting and condensing pump is kept air-tight to some extent by the lubricating material. Now as ether and all kinds of grease are solvents of each other, it is easy to account for a certain amount of escape, which will be difficult to avoid. Liquefied sulphurous acid does not dissolve to any considerable extent in oil, and when free from moisture is without action on metals; and although it might be expected that the packing of the piston might in time be

acted on by sulphurous acid, yet this danger has been entirely obviated by the use of manufactured asbestos packing, which is now being greatly used for high-pressure steam-engines.

When required to work in hot climates, the ice-making machines most generally in use are open to serious objections, and grave inconveniences are experienced in their constant employment. Thus ammoniacal machines work at a pressure of twenty atmospheres, with water at 80° F., and are thus liable to leakage, or even to the danger of an explosion. Methylated ether-machines are open to the same objection, in addition to which there is a danger of fire when a leakage occurs, which unfits them for use at sea.

Now, in the use of sulphurous acid there is the great advantage that at 80° F. its tension does not exceed four atmospheres, while it may be liquefied at 25°, and its tension then is only equal to the pressure of the atmosphere. It has no action upon metals when kept free from water; and in order to obtain it in a perfectly anhydrous condition, M. Pictet prepares it by the action of heat on a mixture of oil of vitriol and sulphur, the gas being dried by oil of vitriol. The condensing and refrigerating apparatus consists of tubular vessels similar to those employed with other liquids, such as ether.

One of these machines is daily at work at the Chelsea Ice Rink, and is capable of making 40 tons of ice per day. The skating-floor, which is the invention of Mr. John Gamgee, consists of a number of flattened metallic tubes placed side by side on a bed of concrete or asphalte; the interior of the tubes is kept filled with an uncongealable mixture of glycerine and water, which is allowed to flow in from an elevated cistern. Clear ice is secured by coating the tubes with water spray, allowing this to freeze, and then sprinkling again. During last winter, tubes of thin sheet-iron were laid on the floating bath on the Thames, at Charing Cross, and a skating-floor was frozen. The temperature of an ice-rink from its agreeable coolness has an exhilarating and bracing influence, which dissipates the languor felt in a warm moist atmosphere.

M. Pictet's machine has interest beyond that of any ordinary economical producer of ice, for, constructed as it is with all the philosophical thought and scientific knowledge which we usually find bestowed only on instruments of research, it has been applied by its inventor to the purpose of establishing certain simple relations between the latent heat, molecular weights, and tensions of the vapours of volatile liquids.

By the application of mathematical reasoning and the use of known data, M. Pictet calculates the latent heat of various liquids, and arrives at the following conclusions:—

1. Cohesion is a constant quantity for all liquids.

2. The derivate of the Napierian logarithm representing the ratio between vapour-tension and temperature, is constant for all liquids, when they are compared under the same circumstances of pressure and temperature.

3. The latent heat of all liquids referred to one and the same pressure, multiplied by the molecular weight referred to a uniform temperature, gives a constant product.

4. For all liquids, the difference between the latent heat at any two temperatures, multiplied by the molecular weight, is a constant number.

5. The latent heat of every liquid is a multiple of its specific heat.

It would be entering too much into detail to give the method by which these very important conclusions have been arrived at, but it may be of interest to some readers to know that an article on the subject was published by M. Pictet in the last volume of the "Philosophical Magazine."

ON VORTEX MOTION.

By Professor OSBORNE REYNOLDS,
Owens College, Manchester.*

IN commencing this discourse the author said, Whatever interest or significance the facts of vortex motion may have, is in no small degree owing to their having, as it were, eluded the close mathematical search which has been made for them, and to their having in the end been discovered in a simple, not to say commonplace, manner. In the Royal Institution it is the custom to set forth the latest triumphs of mind over matter, the secrets last wrested from nature by gigantic efforts of reason, imagination, and the most skilful manipulation. For once, however, it would seem that the case is reversed, and that the triumph rests with nature, in having for so long concealed what has been so eagerly sought, and what is at last found to have been so thinly covered.

The various motions which may be caused in a homogeneous fluid like water, present one of the most tempting fields for mathematical research. For not only are the conditions of the simplest, but the student or philosopher has on all hands the object of his research, which, whether in the form of the Atlantic waves or of the eddies in his teacup, constantly claims his attention. And, besides this, the exigencies of our existence render a knowledge of these motions of the greatest value to us in overcoming the limitations to which our actions are otherwise subject.

Accordingly we find that the study of fluid motion formed one of the very earliest branches of philosophy, and has ever since held its place, no subject having occupied the attention of mathematicians more closely. The results have been, in one sense, very successful; most important methods of reasoning have been developed—mathematical methods, which have helped to reveal numberless truths in other departments of science, and have taught us many things about fluids which most certainly

* A lecture delivered at the Royal Institution, February 2, 1877, and printed here by permission of the author.

we should not otherwise have found out, and of which we may some day find the application. But as regards the direct object in view, the revelation of the actual motion of fluids, the research has completely failed. And now that generations of mathematicians have passed away, now that the mysteries of the motions of the heavenly bodies, of the earth itself, and almost of every piece of solid matter on the earth have been explained by mathematicians, the simplest problems of fluid motion are yet unsolved.

If we draw a disc flatwise through the water, we know by a process of unconscious geometrical reasoning that the water must move round the disc; but by no known mathematical process could the motion be ascertained from the laws of motion. If we draw the plate obliquely through the water we experience a greater pressure on the one side than on the other. Now this case, representing as it does the principle of action of the screw-propeller, is of the very highest importance to us; and yet, great as has been the research, it has revealed no law by which we may in a given case calculate the resistance to be obtained, or indeed tell from elementary principles in what way the water moves to let the plate pass. Again, the determination of the resistance which solid bodies, such as ships, encounter is of such exceeding economic importance, that theory, as shipbuilders call it, having failed to inform them what to expect, efforts have been, and are still being, made to ascertain the laws by direct experiment. Instances might be multiplied, but one other must suffice. If we send a puff of fluid into other fluid we know that it will travel to a considerable distance, but the manner in which it will travel and the motion it will cause in the surrounding fluid, mathematics have not revealed to us.

Now the reasons why mathematicians have been thus baffled by the internal motions of fluids appear to be very simple. Of the internal motions of water or air we can see nothing. On drawing the disc through the water there is no evidence of the water being in motion at all, so that those who have tried to explain these results have had no clue; they have had not only to determine the degree and direction of the motion, but also its character.

But although the want of a clue to the character of the motion may explain why so little has been done, it is not so easy to understand how it is that no attempts were made to obtain such a clue. It would seem that a certain pride in mathematics has prevented those engaged in these investigations from availing themselves of methods which might reflect on the infallibility of reason.

Suggestions as to the means have been plentiful. In other cases where it has been necessary to trace a particular portion

of matter in its wanderings amongst other exactly similar portions, ways have been found to do it. It may be argued that the influences which determine the path of a particular portion of water are slight, subtle, and uncertain, but not so much so as those which determine the path of a sheep. And yet thousands of sheep belonging to different owners have been from time immemorial turned loose on the mountains, and although it probably never occurred to anyone to reason out the paths of his particular sheep, they have been easily identified by the aid of a little colour. And that the same plan might be pursued with fluids, every column of smoke has been evidence.

But these hints appear to have been entirely neglected, and it was left for Nature herself, when, as it were, fully satisfied with having maintained her secret so long, and tired of throwing out hints which were not taken, at last to divulge the secret completely in the beautiful phenomenon of the smoke ring. At last; for the smoke ring is probably a phenomenon of modern times. The curls of smoke, as they ascend in an open space, present to the eye a hopeless entanglement; and although, when we know what to look for, we can see as it were imperfect rings in almost every smoke cloud, it is rarely that anything sufficiently definite is formed to attract attention, or suggest anything more important than an accidental curl. The accidental rings, when they are formed in a systematic manner, come either from the mouth of a gun, the puff of a steam-engine, or the mouth of a smoker, none of which circumstances existed in ancient times.

Although, however, mathematicians can in no sense be said to have discovered the smoke ring, or the form of motion which it reveals, they were undoubtedly the first to invest it with importance. Had not Professor Helmholtz some twenty years ago called attention to the smoke ring by the beautiful mathematical explanation which he gave of its motion, it would in all probability still be regarded as a casual phenomenon, chiefly interesting from its beauty and rarity. Following close on Helmholtz came Sir William Thomson, who invested these rings with a transcendental interest by his suggestion that they are the type after which the molecules of solid matter are constituted.

The next thing to enhance the interest which these rings excited, was Professor Tait's simple and perfect method * of pro-

* The apparatus consists of a cubical box like a tea-chest, with a circular hole, six or eight inches in diameter, in its bottom, and a cloth loosely nailed over the top in place of a lid. The box is set on its end. The fumes of hydrochloric acid and ammonia are separately introduced into the box, when they combine and form a dense smoke, which is ejected from the orifice by patting the cloth. It appears that a somewhat similar form of apparatus was used by Faraday, and has long been known as a toy.—O. R.

ducing them at will, and thus rendering them subjects for lecture-room experiments. Considering that this method will probably play a great part in perfecting our notions of fluid motion, it is an interesting question how Professor Tait came to hit upon it. There is only one of the accidental sources of these rings which bears even a faint resemblance to this box, and that is the mouth of a smoker as he produces these rings. This might have suggested the box to Professor Tait. But since this supposition involves the assumption that Professor Tait sometimes indulges in a bad habit, and as we all know that Professor Tait is an eminent mathematician, perhaps we ought rather to suppose that he was led to his discovery by some occult process of reasoning which his modesty has hitherto kept him from propounding.

But however this may be, his discovery was a most important one, and by its means the study of the actual motion of these rings has been carried far beyond what would otherwise have been possible.

But it has been for their own sake, and for such light as they might throw on the constitution of matter, that these rings were studied. The most important lesson which they were capable of teaching still remained unlearned. It does not appear to have occurred to anyone that they were evidence of a general form of fluid motion, or that the means by which these had been revealed, would reveal other forms of motion.

There was, however, at least one exception, which will not be forgotten in this room: the use of smoke to show the effect of sound upon jets of air.

Also, the late Mr. Henry Deacon, in 1871, showed that minute vortex rings might be produced in water by projecting a drop of coloured water from a small tube. And his experiments, in spite of their small scale, excited considerable interest.

Four years ago, being engaged in investigating the action of the screw-propeller, and being very much struck by the difference between some of the results he obtained and what he had been led to expect, the author made use of colour to try and explain the anomalies, when he found that the vortex played a part in fluid motion which he had never dreamt of; that, in fact, it was the key to almost all the problems of internal fluid motion. That these results were equally new to those who had considered the subject much more deeply than he had, did not occur to him until after some conversation with Mr. Froude and Sir William Thomson.

Having noticed that the action of the screw-propeller was greatly affected when air was allowed to descend to the blades, he was trying what influence air would have on the action of a simple oblique vane, when a very singular phenomenon presented

itself. The air, instead of rising in bubbles to the surface, ranged itself in two long horizontal columns behind the vane. There was evidence of rotational motion about these air lines. It was evident, in fact, that they were the central lines of two systematic eddies.

That there should be eddies was not surprising, but eddies had always been looked upon as necessary evils which beset fluid motion as sources of disturbance, whereas here they appeared to be the very means of systematic motion.

Here then was the explanation of the nature of the motion caused by the oblique vane, a cylindrical band of vortices continually produced at the front of the plate, and falling away behind it in an oblique direction.

The recognition of the vortex action caused behind the oblique vane, suggested that there might be similar vortices behind a disc moving flatwise through the water, such as are the eddies caused by a teaspoon.

There was one consideration, however, which at first seemed to render this improbable. It was obvious that the resistance of the oblique vane was caused in producing the vortices at its forward part; so that if a vortex were formed behind a flat plate, as this vortex would remain permanently behind, and not have to be continually elongated, the resistance should diminish after the plate was once set in motion; whereas experience appeared to show that this was by no means the case. It appeared probable, therefore, that from some disturbing cause the vortex would not form, or would only form imperfectly, behind the plate.

This view was strengthened when, on trying the resistance of a flat plate, it did not appear to diminish after the plate had been started.

Accidentally, however, it was found that if the float to which the plate was attached was started suddenly and then released, the float and plate would move on apparently without any resistance. And more than this, for if the float were suddenly arrested and released, it would take up its motion again, showing that it was the water behind that was carrying it on.

There was evidence therefore of a vortex behind the disc. In the hope of rendering this motion visible, coloured water was injected in the neighbourhood of the disc, and then a beautiful vortex ring, exactly resembling the smoke ring, was seen to form behind the disc. If the float were released in time, this ring would carry the disc on with it; but if the speed of the disc were maintained uniform, the ring gradually dropped behind and broke up. Here then was another part played by the vortex previously undreamt of.

That the vortex takes a systematic part in almost every form

of fluid motion was now evident. Any irregular solid moving through the water must from its angles send off lines of vortices such as those behind the oblique vane. As we move about we must be continually causing vortex rings and vortex bands in the air. Most of these will probably be irregular, and resemble more the curls in a smoke cloud than systematic rings. But from our mouths as we talk we must produce numberless rings.

One way in which rings are produced in perhaps as great numbers as from our mouths is by drops falling into the sea. If we colour the surface of a glass vessel full of water, and then let drops fall into it, rings are produced, which descend sometimes as much as two or three feet.

But the most striking rings are those produced in water, in a manner similar to that in which the smoke rings are produced, using coloured water instead of smoky air.

These rings are much more definite than smoke rings, and although they cannot move with higher velocities, since that of the smoke ring is unlimited, the speed at which they move is much more surprising.

In the air we are accustomed to see objects in rapid motion, and so far as our own notions are concerned, we are unaware of any resistance; but it is quite otherwise in water. Every swimmer knows what resistance water offers to his motions, so that when we see these rings flash through the water we cannot but be surprised. Yet a still more striking spectacle may be shown, if, instead of coloured water, a few bubbles of air be injected into the box from which the puff is sent; a beautiful ring of air is seen to shoot along through the water, showing, like the lines of air behind the oblique vane, little or no tendency to rise to the surface.

Such is the ease with which these vortex rings in water move, and so slight is the disturbance which they cause in the water behind them, as to lead to the conclusion that they experience no resistance whatever, except perhaps a little caused by slight irregularities in their construction. Their velocity gradually diminishes; but this would appear to be accounted for by their growth in size, for they are thus continually taking up fresh water into their constitution, with which they have to share their velocity. Careful experiments have confirmed this view. It is found that the force of the blow they will strike is nearly independent of the distance of the object struck from the orifice.

The discovery of the ring behind the disc afforded the opportunity of observing the characteristics of these rings much better than was afforded by the smoke rings; and also suggested facts which had previously been overlooked. The manner of

motion of the water which formed the ring and of the surrounding water was very clearly seen. It was at once seen that the visible ring, whether of coloured water or air, was merely the central line of the vortex; that it was surrounded by a mass of moving water, bearing somewhat the same proportion to the visible ring as a ball made by wrapping string (in and out) round a curtain ring until the aperture was entirely filled up. The disc, when it was there, formed the front of this ball or spheroid of water, but the rest of the surface of the ball had nothing to separate it from the surrounding water but its own integrity. Yet when the motion was very steady the surface of the ball was definite, and the entire moving mass might be rendered visible by colour. The water within the ball was everywhere gyrating round the central ring, as if the coils of string were each spinning round the curtain ring as an axis, the water moving forwards through the interior of the ring and backwards round the outside, the velocity of gyration gradually diminishing as the distance from the central ring is increased.

The way in which the water moves to let the ball pass can also be seen, either by streaking the water with colour or suspending small balls in it. In moving to get out of the way and let the ball of water pass, the surrounding water partakes as it were of the gyrating motion of the water within the *ball*, the particles moving in a horse-shoe fashion, so that at the actual surface of the *ball* the motion of the water outside is identical with that within, and there is no rubbing at the surface, and consequently no friction.

The maintenance of the shape of the moving mass of water against the unequal pressure of the surrounding water as it is pushed out of the way is what renders the internal gyratory motion essential to a mass of fluid moving through a fluid. The centrifugal force of this gyratory motion is what balances the excess of pressure of the surrounding water in the front and rear of the ball, compared with what it is at the sides.

It is impossible to have a ring in which the gyratory motion is great, and the velocity of progression slow. As the one motion dies out so does the other; and any attempt to accelerate the velocity of the ring by urging forward the disc, invariably destroyed it.

The striking ease with which the vortex ring, or the disc with the vortex ring behind it, moves through the water, naturally raised the question as to why a solid should experience resistance. Could it be that there was something in the particular spheroidal shape of these balls of water which allowed them to move freely? To try this, a solid of the same shape as the fluid ball was constructed and floated after the same manner as the disc. But when this was set in motion, it stopped directly—it

would not move at all. What was the cause of this resistance? Here were two objects of the same shape and weight, the one of which moved freely through the water, and the other experienced very great resistance? The only difference was in the nature of the surface. As already explained, there is no friction at the surface of the water, whereas there must be friction between the water and the solid. But it could be easily shown that the resistance of the solid is much greater than what is accounted for by its surface friction or skin resistance. The only other respect in which these two surfaces differ is that the one is flexible, while the other is rigid, and this seems to be the cause of the difference in resistance.

If ribbons be attached to the edge of the disc, these ribbons will envelope the ball of water which follows it, presenting a surface which may be much greater than that of the solid; and yet this, being a flexible surface, the resistance of the disc with the vortex behind it is not very much greater than it would be without the ribbons—nothing to be compared to that of the solid.

Colouring the water behind the solid shows, that instead of passing through the water without disturbing it, there is very great disturbance in its wake. An interesting question is as to whether this disturbance originates with the motion of the solid, or only after the solid is in motion. This is settled by colouring the water immediately in front of the solid before it is started. Then on starting it the colour is seen to spread out in a film entirely over the surface of the solid, at first without the least disturbance, but this follows almost immediately.

Among the most striking features of the vortex rings, is their apparent elasticity. When disturbed they not only recover their shape, but vibrate about their mean position like an elastic solid. So much so, as to lead Sir William Thomson to the idea that the elasticity of solid matter must be due to its being composed of vortex rings.

But apart from such considerations, this vibration is interesting as showing that the only form of ring which can progress steadily is the circular. Two parallel bands, such as those which follow the oblique vane, could progress if they were infinitely long, but if not, they must be continually destroyed from the ends. Those which follow the oblique vane are continually dying out at one end, and being formed again at the other.

If an oval ring be formed behind an oval plate, the more sharply curved parts travel faster than the flatter parts; and hence, unless the plate be removed, the ring breaks up. It is possible, however, to withdraw the plate, so as to leave the oval ring, which proceeds wriggling along, each portion moving in a direction perpendicular to that in which it is curved, and with

a velocity proportional to the sharpness of the curvature. So that not only does the ring continually change its shape, but one part is continually falling behind, and then overtaking the other.

These are some of the forms of fluid motion which imagination or reason had failed to show us, but which have been revealed by the simple process of colouring the water.

Now that we can see what we are about, mathematics can be most usefully applied; and it is expected that when these facts come to be considered by those best able to do so, the theory of fluid motion will be placed on the same footing as the other branches of applied mechanics.

REVIEWS.

FIELD GEOLOGY.*

OF the many elementary treatises and text-books prepared for the geological student, scarcely any treat of the method of observation in the field, or if so, only in a very general way. The "How to Observe," by De la Beche, and the "Guide du Géologue-Voyageur," by A. Boué, contain many valuable suggestions bearing on the subject, and may still be consulted with advantage. A good practical work has been long a desideratum, and this is to a great extent supplied by the "Field Geology" of Mr. Penning.

What to observe, how to observe, and how to record observations in the field, are important parts of geological study; and all theoretical knowledge derived from hand-books by the student of geology, should if possible be supplemented, as in the medical curriculum, by clinical instruction and observation at the bedside. For one of the real objects of inquiry in the field is to understand, when examining a section in a quarry or a sea-cliff, the nature of the various beds, and the conditions under which they were accumulated. In these respects the chapters on Lithology and Palæontology (chaps. iii. and iv.) will be of service, although the latter chapter might be corrected and improved; a dry list of fossils, without a knowledge of their bearings, being of little use.

The chapters devoted to geological mapping and sections form an important part of the book, as these are essential elements in understanding the structure of a country. The operations and the means of carrying them out are clearly given by the author, and are accompanied by tables and plans which render the text clearer, especially as regards the drawing of boundary lines, a practical matter of considerable importance, instruction in which has been somewhat neglected.

With this view the author first describes the necessary instruments used in field-surveying, and then proceeds in a very systematic and detailed manner to show their applications, and the methods by which the tracing of geological boundaries is effected and the construction of horizontal sections carried out; as well as how errors may arise in the latter case if the

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* "Field Geology." By W. H. Penning, F.G.S.; with a section on Palæontology, by A. J. Jukes-Browne, B.A., F.G.S. Sm. 8vo. London: Baillière, Tindall, & Cox. (No date.)

surface of the ground along the line of such section is not accurately represented.

The last two chapters contain (1) the practical application of geological surveying, involving the methods and operations described in the preceding pages, and (2) the way in which geological knowledge and reasoning may be turned to account with regard to the supply of water and the origin and character of soils.

The book is a useful addition to geological literature, and no earnest student of the science should fail to consult it, and carry out in the field the instructions contained in its pages, which the author has rendered as concise as possible, in order to facilitate the acquirement of a knowledge of field geology, and to embody in a small compass practical directions and suggestions which are to be found only here and there in more important works.

THE GERM-THEORY OF DISEASE.*

THE author of this very ingenious book explains contagion and the course of fevers by the theory of special germs being introduced from without into the body. "The theory is, that many diseases are due to the presence and propagation in the system of animal organisms having no part or share in its normal economy. This it is, and no more. It is essential to be clear on this point; for the opponents of the germ-theory, and, to some extent, its advocates also, have introduced into the discussion of that theory the questions of the source and mode of origin of these organisms—a complication which has tended to hamper men's minds and to divert attention from the real subject of discussion—*the competence of germs to produce the phenomena of disease.*" The morbific agent propagated in and given off from the bodies of the sick—a *contagium*—may gain entrance into other bodies through the lungs or the alimentary mucous surface. This is an organic body too small to be seen except through the agency of the electric beam, and which propagates in the blood and acts as a parasite. The shiver of fever is produced by a sudden and enormous development of the germs, and the non-elimination of urea to their demanding nitrogen. Just as micrococci are visible in the tissues affected by diphtheria, so these infinitely small germs do equivalent mischief. We must hope for some new treatment which will settle these germs, and until that is discovered we must be in the same condition as we were in our beliefs thirty years ago, when Southwood Smith decided that fever was from want of oxygen, and because salt made the fever-blood red and arterial-looking, salted, and sometimes cured his patients. As a matter of fact, did not Sir Henry Holland elaborate the germ-theory thirty years ago?

The book is well worth reading, and is sufficiently free from professional technicalities, so that it may be read by the public with advantage.

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* "The Germ-Theory Applied to the Explanation of the Phenomena of Disease. The Specific Fevers." By T. Maclagan, M.D. 8vo, London: Macmillan. 1877.

FOSSIL CRUSTACEA.*

PERHAPS no more striking example of the usefulness of the process of taking stock in scientific matters could very well be adduced than the "Catalogue of British Fossil Crustacea" just prepared by Mr. Henry Woodward, and published by the Trustees of the British Museum. Little more than twenty years ago, when Professor Morris brought out the second edition of his admirable "Catalogue of British Fossils," he recorded only 306 species of crustaceans. The advance in this department of palæontology has since been so great that Mr. Woodward can now number no fewer than 979 distinct species, besides 72 named varieties. The number has thus been considerably more than trebled in twenty years, and when we remember that for the most part the additions have been made sporadically, that is to say, by scattered descriptions and notices in a great number of books and papers, it will easily be seen that Mr. Woodward has a strong claim upon the gratitude of all students of palæontology for the labour he has undergone in producing his present work. And this labour is by no means small; the catalogue contains not only a classified enumeration of the known British crustacean fossils, with particulars of the formations and localities in which they occur, but also a full synonymy of both genera and species. Mr. Woodward is so well known as a careful and conscientious student of the fossil remains of this class of animals, that it is almost unnecessary to say that his work is thoroughly well done, and will prove a most valuable aid to all future investigators.

The study of the fossil crustacea presents many points of high interest. They are, as Mr. Woodward well indicates, among the very oldest of undoubted organic remains. Leaving the Laurentian *Eozoon* out of the question, as still of somewhat uncertain nature, the Lower Cambrian deposits of the St. David's district of South Wales have furnished various geologists, and especially Mr. Henry Hicks, with a series of fossils among which crustaceans occupy the very first rank, not only as regards their number when compared with the fossil organisms of other groups, but also as presenting a complexity of organization which would seem to indicate that even at that remote period of the earth's history they must have had already a long series of predecessors. Trilobites, some of them of large size and very complex structure, can hardly be regarded as representing the earliest realization even of the crustacean type; and their occurrence so low down in the series of stratified rocks may serve as an encouragement to geologists to search elsewhere in deposits of still greater antiquity for traces of the dawn of life.

Starting from this point the crustacea go on through the whole series of fossiliferous deposits, acquiring a greater and greater variety of form and organization as they advance towards the present day. Of the thirteen orders into which Mr. Woodward divides the class, only two have become

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* "A Catalogue of British Fossil Crustacea, with their synonyms and the range in time of each genus and order." By Henry Woodward, F.R.S., F.G.S. 8vo. Printed by order of the Trustees of the British Museum. London. 1877.

extinct, namely, the Trilobita and the Eurypterida, which are confined to the Palæozoic formations; of three other orders, the Cladocera, the Copepoda, and the singular parasitic Rhizocephala, no fossil representatives are known; but from the Jurassic epoch onwards, all the rest of the orders appear to be more or less abundantly represented. Of the parasitic forms, some of which are among the most interesting of existing crustacea, one can scarcely expect any traces to be preserved, but even of these there are indications of the existence of one species of *Bopyrus*, parasitic under the carapace of a crab, in the Cambridge Green-sand. Of several other groups, the number of known fossil representatives is but small when compared with the abundance of forms living at the present day, and in some cases this can hardly be due to the easy destructibility of the animals, which is undoubtedly the cause of the disappearance of the parasites. Many hitherto unknown forms belonging to these groups will probably reward the labours of zealous searchers among the rocks; and to all who may endeavour to fill up the gaps in our knowledge, either by the discovery of new forms or by making us better acquainted with the structure and characters of those numerous species which are still but imperfectly known, Mr. Woodward's catalogue will be an invaluable boon.

THE STEAM ENGINE.*

THOSE who wish to understand the theory and action of the steam-engine, but can bring to bear upon the subject scarcely more mathematics than ordinary arithmetic, will no doubt be grateful to Mr. Northcott for the trouble he has taken to simplify the subject. After a slender sketch of the history of the engine, he discusses briefly such questions as the formation of coal, the origin of force, and the nature of combustion. As to the thermal values of different forms of fuel, their behaviour in the furnace, and the best conditions for transferring heat from the furnace to the boiler, these are subjects so important to everyone who uses a steam-engine that we are glad to see them discussed with some fulness. The reader must not expect to find in this work a description of the constructive details of the various forms of steam-engine, but nevertheless the author describes the action of the mechanism, and compares the various forms of engine with respect to their efficiency. Several indicator-diagrams are given, and explained at some length. The work also contains some useful tables, which have evidently cost the author much labour in their compilation. To render the subject intelligible to the practical engineer was Mr. Northcott's principal object, but at the same time he has aimed at securing precision. Anyone who does not feel equal to facing such works as those of Rankine may dip with profit into Mr. Northcott's volume.

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* "The Theory and Action of the Steam Engine, for Practical Men." By W. H. Northcott, C.E., &c. 8vo. London: Cassell, Petter & Galpin.

MEASURING MACHINES.*

IT is hardly too much to say that the power of producing true surfaces lies at the bottom of all machine construction. When Watt first constructed his steam-engine one of his great difficulties consisted in making the piston fit true to the cylinder. Such extreme precision has, however, since been obtained that we are now able to detect the difference of fit in two pistons though they may not differ by more than the ten-thousandth of an inch in diameter. This great advance in the construction of machinery of precision is due mainly to the exertions and ingenuity of Sir Joseph Whitworth, who has spared no pains to effect improvements in this direction. His steel "surface-plates" are indeed the nearest approach to absolutely true planes which human ingenuity has yet contrived. So true, in fact, are these surfaces that if a piece of gold-leaf be rubbed between them it entirely disappears, its molecules being forced into the pores of the steel. Sir Joseph's standard gauges are likewise marvels of mechanical skill. Professors Goodeve and Shelley have therefore rendered no small service to students of mechanics by putting before them clear descriptions of these instruments of precision, but above all by describing the beautiful measuring machine with which the name of Whitworth will always be associated.

There are two ways in which minute linear magnitudes may be gauged; one being the old method of measurement by means of the micrometer and microscope; the other being the method of "end measurement," which relies upon truth of surface and delicacy of touch. The latter is the principle on which the Whitworth machine is based. At first sight it may seem strange that minute differences of magnitude should be more readily detected by the sense of feeling than by the eye aided by the microscope. Yet Sir J. Whitworth has shown beyond doubt that this is the case. Workmen in securing a good mechanical fit usually depend on touch, and the "feeling piece" attached to the Whitworth machine can be manipulated with extreme delicacy.

It must be remembered that Sir Joseph's measuring machine is not intended so much for measuring the actual length of a bar as for determining very minute differences in the lengths of specially prepared bars; hence it is peculiarly adapted for multiplying copies of standards of length. For use in the workshop a Whitworth machine is constructed to indicate a difference of one ten-thousandth of an inch; but the great triumph is the far more delicate instrument by which a difference of a millionth of an inch may be detected. To understand the construction of this beautiful instrument the reader must refer to the series of plates attached to the work of Professors Goodeve and Shelley.

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* The Whitworth Measuring Machine, including Descriptions of the Surface Plates, Gauges, and other Measuring Instruments made by Sir Joseph Whitworth, Bart., &c. By T. M. Goodeve, M.A., &c., and C. P. B. Shelley, C.E., &c. With four plates and 44 woodcuts. 8vo. London: Longmans. 1877.

AMERICAN PUBLICATIONS.

AMERICAN publications which we must regard as more or less national in their character continue to reach us with astonishing voluminousness, leading us to admire more and more the liberality of the Governments of the United States.

Foremost among them we must notice the Bulletin* of that wonderful institution the "Geological and Geographical Survey of the Territories" which, under the guidance of its chief, Dr. F. V. Hayden, has done so much good work in making known the structure and productions of those far-western regions which not many years ago formed almost a *terra incognita*. Of this most admirable repertory we have received the second and third numbers of Vol. III., the first having unfortunately not reached us. Number 2, a stout part of 340 pages, is exclusively devoted to the description of the species of certain groups of Arthropoda, collected during the surveying expeditions into the Western Territories. It contains a long paper on "Western Diptera," by Baron Osten Sacken; a report by Dr. P. R. Uhler on the insects collected by him in 1875, with descriptions of Hemiptera collected by Dr. Packard; and descriptions of spiders from Colorado, by M. T. Thorell. In the second of these papers Dr. Uhler introduces a sort of monographic treatment of two families of Hemiptera, the Cydnidæ and the Saldidæ, which will be of much use to students, but here and in other parts of his paper we regret to see what appears to be a reckless multiplication of generic groups. It must be confessed, indeed, that Dr. Uhler has a sufficient number of companions to keep him in countenance in his iniquities, but we cannot but feel that the true comprehension of the relations of organisms will be rather retarded than forwarded by the analytical process which is carried on by nearly all the zoologists of our day, the accepted notion being apparently that wherever a slight difference can be indicated a generic name must be imposed. M. Thorell's paper relates solely to the true spiders of the Colorado district, of which he describes a good many new species.

The contents of Number 3 are of a more miscellaneous nature. The ethnologist will find a comparative vocabulary of the dialects of the Indians of Utah, which is followed by a short note on the methods of making stone weapons, illustrated with a plate. Dr. A. C. Peale notices some peculiar eruptive "igneous and yet non-volcanic" mountain masses in Colorado, on which he hangs certain considerations as to the geological history of the district. Professor Cope contributes a report on the Judith River formation and on vertebrate fossils obtained by him from it and from other deposits on and near the Missouri, in which he describes many reptilian remains; whilst Dr. C. A. White describes the *Uniones* and other freshwater mollusca collected by Professor Cope, and also some from the tertiaries of Wyoming and Utah, gives a catalogue of the known invertebrate fossils from the fresh and brackish water deposits of Western North America, compares the North

* Bulletin of the United States Geological and Geographical Survey of the Territories, vol. iii. Nos. 2 and 3. 8vo. Washington. 1877.

American Mesozoic and Cænozoic Unionidæ and associated mollusca with living species, and discusses the palæontology of the same formations in the Green River region.

The zoological papers are not numerous, but what there are are of considerable interest. Dr. Elliott Coues contributes some notes on the North American forms of insectivorous mammals, which appear to be preliminary to a complete monograph of the group, the North American species of which, although not numerous and belonging to only two families, have already been the subjects of considerable diversity of opinion. Mr. C. A. H. McCauley's notes on the ornithology of the region about the source of the Red River of Texas, which are annotated by Dr. Elliott Coues, are also an important contribution. Besides furnishing a list of the bird-inhabitants of an out-of-the-way locality, they give a good deal of information upon the habits of the species observed. A catalogue of the land and freshwater shells of Nebraska by Dr. Aughey, a formidable list for a single State, and a report by Mr. A. D. Wilson on the geographical work of the Survey, conclude the 3rd number of this Bulletin for 1877.

Another publication under the auspices of the Survey of the Territories is the Bulletin of the Entomological Commission,* two parts of which have reached us. Both these pamphlets are devoted to the consideration of that terrible scourge of the western farmer, the Rocky-Mountain locust (*Caloptenus spretus*) whose ravages appear to be extending further and further east with each succeeding year. The second part contains an admirable account of the natural history of this pest, illustrated with a map showing the extent of country infested by it; the first part deals solely with the methods to be adopted for destroying the young, or, as our American cousins with their usual fondness for idiomatic expressions prefer to call them, "unfledged" locusts. The Entomological Commission consists of MM. Riley, Packard, and C. Thomas.

Other Government publications that we have received, are Professor Newcomb's "Investigation of Corrections to Hansen's Tables of the Moon," forming Part 3 of papers published by the U. S. Transit of Venus Commission, an investigation undertaken for the purpose of enabling the longitudes of the observation-stations to be accurately determined; and the volume of Astronomical and Meteorological Observations for 1874,† published in the present year. The last-named volume carries its own description with it; but we may notice that besides the ordinary tables of the results of observations, it contains an appendix giving a most interesting description of the astronomical instruments in the Observatory (one of them being a magnificent 26-inch equatorial), illustrated with heliotype representations of the different instruments, and also a second appendix on the difference of longitude between Washington and Ogden, Utah.

The Seventh Annual Report of the Massachusetts State Board of Health,‡

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* Bulletin of the United States Entomological Commission. Parts 1 & 2. 8vo. Washington. 1877.

† "Astronomical and Meteorological Observations made during the year 1874 at the United States Naval Observatory." Rear-Admiral C. H. Davis, Superintendent. 4to. Washington. 1877.

‡ "Seventh Annual Report of the State Board of Health of Massachusetts. January, 1876." 8vo. Boston. 1876.

is a stout volume of 550 pages, with numerous plates and folding maps and plans. The most important portion of its contents consists of reports on the pollution of rivers and the disposal of sewage, questions which are already forcing themselves on the inhabitants of the older States almost as unpleasantly as upon ourselves. These reports are very elaborate, and many comparisons are made with the state of things prevailing on this side of the water. Some sanitary hints, and especially a treatise on defects in house-drainage by Mr. E. S. Philbrick, are also of interest.

We have still to notice the publications of the Smithsonian Institution, which, as usual, are of great value. The Report for 1875,* the last that has reached us, contains as usual an elaborate statement of the doings of this most admirable body, with an appendix in which, besides several translations and reprints, we find some original memoirs of considerable importance, chiefly on anthropological subjects. Mr. H. Gillman has a curious paper on "Certain Characteristics pertaining to Ancient Man in Michigan," in which he records the very frequent occurrence of perforated humeri in the mounds on the Detroit and Rouge rivers, this peculiar formation being met with in about 50 per cent. of the number found. It is remarkable as being associated with platycnemism. Mr. Gillman also describes and figures several examples of artificially perforated skulls from the mounds of the same region. A very long and elaborate paper, by Dr. C. C. Abbott, treats of the remains of the stone age in New Jersey, and is illustrated by upwards of 200 figures of stone implements, advancing from rudely-chipped forms to those of more careful construction, ground and even engraved. The objects include some tobacco-pipes of stone, and pottery of various patterns.

Two parts of the Smithsonian Contributions,† published in 1876, also go back over this antiquarian ground, which, although as compared with the archæology of the old world, it may be in part comparatively modern, is certainly to a considerable extent prehistoric so far as America is concerned. Dr. Joseph Jones gives a most interesting account of his explorations of the aboriginal remains of Tennessee, the burial caves, stone-graves, mounds and earthworks, and the numerous objects obtained from them. Many of the latter are very curious and interesting. Dr. Jones finds that the crania of the stone-grave and mound-building race of Tennessee belong to the Toltecan division of American nations, agreeing markedly with those of the Inca Peruvians and the Toltecs of Mexico. They have usually been altered by pressure. Many of these crania also bear a striking resemblance to those of the Natchez, and hence Dr. Jones infers that the aborigines of Tennessee were probably descended from the Toltecs, and related to the Natchez, and endeavours from an examination of historical documents relating to the early knowledge of this part of America, to ascertain what may have been the history of these extinct people. He notes that the mode of burial in stone coffins or cists adopted by them

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* "Annual Report of the Board of Regents of the Smithsonian Institution, for the year 1875." 8vo. Washington. 1876.

† "Smithsonian Contributions to Knowledge." Nos. 259 and 267. 4to. Washington. 1876.

differs from that practised by any other North American tribe; further, they were idolaters, and the physiognomy of many of their idols more or less resembles that of some of the Toltec idols. Both the headdresses and physiognomy of some of the idols are suggestive of an Eastern or Chinese origin. Their connection with Central America and the Gulf of Mexico is indicated by the presence of numerous large sea-shells in the mounds, by the representation of Central American birds and animals on their pipes and culinary vessels, and by their making use of obsidian, fluor-spar, and serpentine for constructive purposes.

The description of the "Archæological Collection of the United States National Museum," by Mr. Charles Rau, which forms the second part of the Smithsonian Contributions for 1876, is a most important contribution to the knowledge of American archæology. Implements, weapons, and ornaments, articles of stone, clay, metal, wood, shell, bone, and horn, are most carefully described and profusely illustrated, so that the book will form an excellent treatise of reference for all future students.

ELEMENTARY PHYSICS.*

NO branch of science is more popular than that which we used to call Natural Philosophy, and which most people now-a-days call Physics. Nor is this to be wondered at. For the forces of nature, though unseen themselves, are constantly manifest in their effects upon the world of matter around us; and a person endowed with ordinary curiosity must needs be anxious to learn something about such phenomena as those of gravitation, heat, light, and electricity. For imparting a sound knowledge of physics, we can hardly point to any better elementary work than the well-known Treatise of Deschanel, which has been much improved by Professor Everett in the English translation. But this beautifully-illustrated work is perhaps a little too elaborate for the beginner, and hence the translator and publisher have thought fit to bring out an introductory text-book, dealing with similar subjects. The result is the excellent little work now in our hands. What should, and what should not, be introduced into such a work is, of course, in large measure a matter of individual opinion; but Professor Everett, as a teacher of long experience, has in most cases exercised great judgment in the selection of his materials. The wisdom of his discretion is seen in the way in which he avoids details, whilst dwelling on general principles; not cramming the beginner with a multitude of facts, but rather teaching him to connect a few great facts together. It need hardly be said that the most modern views are everywhere introduced, and that Professor Everett has taken an early opportunity of employing the modern C. G. S. system of units; that is to say, the Centimetre, the Gramme, and the Second are taken as the units respectively of length, mass, and time. A *Dyne* is the new name for the *unit of force*; a dyne is therefore that force which, acting upon a mass

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* "Elementary Text-book of Physics." By J. D. Everett, M.A., D.C.L. F.R.S.E., &c. Sm. 8vo. London: Blackie & Son. 1877.

of one gramme, produces a velocity of one centimetre per second. Again, the term *Erg* is used to denote the *unit of work*, or the work done by a force of one dyne acting through a distance of one centimetre. Before leaving the volume, it should be remarked that each section is accompanied by a set of well-chosen problems. Altogether the work is admirably adapted to the wants of teachers who really desire to give their students a solid groundwork in the principles of physical science.

PHYSICS OF THE ETHER.*

IN this work an attack is made with considerable energy on two giants, which unfortunately are but straw-stuffed—the allied theories, as the author calls them, of "action at a distance" and "potential energy." As a mere matter of fact, scientific men do not even use the words "action at a distance" as the title of any theory; and what they understand as "potential energy" is not by any means what our author supposes. Newton's gravity, which our author supposes to be an example of force assumed to act at a distance, "without the intervention of material or physical agency," was not so understood by Newton himself, who may be presumed to have known what he meant by it. He distinctly pronounced the idea inconceivable, that a body can act on another, or through a vacuum, without the intervention of anything else by or through which the force may be conveyed from one to another. Towards the close of his "Principia," he says: "We have explained the phenomena of the heavens, and of our sea, by the power of gravity, but have not yet assigned the cause of the power." And then, after showing what may certainly be inferred respecting gravity, he proceeds, "I have not hitherto been able to discover the cause of these properties of gravity from phenomena, and I frame no hypotheses." One hypothesis only did he actually consider, the hypothesis namely of action at a distance, but only to reject it, as one which no one could for a moment entertain "who has in philosophical matters a competent faculty of thinking." So, too, of electricity. Our author is quite mistaken in supposing that it is regarded by men of science as acting at a distance in his sense of the words. Nor again are either gravity or electricity supposed to act with infinite rapidity. Mr. Preston says, "if we take the case of an electro-magnet and a piece of iron, then, when the electro-magnet is suddenly put in the magnetic condition by the electric current, it is assumed in accordance with the theory of action at a distance that the agency by which the distant piece of iron is put in motion requires no time to pass from the magnet to the iron." Nothing of the sort is assumed. No reference is made to the time required in this case, any more than in speaking of a luminous object at a short distance we mention the time which the light requires to travel from it to the eye, for the time is practically evanescent; but it is no more regarded as absolutely evanescent in the case of magnetic

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* "Physics of the Ether" By S. Tolver Preston. 8vo. London: E. & F. N. Spon. 1875.

attraction than in the case of light, where it is known certainly not to be evanescent. All we assert of gravity is that its action certainly travels with a velocity enormously exceeding that of light. This is known from phenomena. What its velocity is we have no means of determining, simply because the motions of the heavenly bodies show as yet no signs of the finiteness of the velocity with which the action of gravity is transmitted. This velocity is therefore practically infinite, that is, it is infinite in the same sense in which the velocity of light is infinite in ordinary terrestrial observations.

"Potential energy" is an expression really belonging to modern science; but it is not what Mr. Preston supposes. It *is* in one sense a form of energy depending on position, precisely as the tension of an elastic string connecting two bodies depends on the position of the bodies; but it can no more be said to depend on position only than can the tension of such a string. We do not know what it actually depends on besides position, for we do not know how gravity is caused; and we do know what the tension of the string depends on, for we can see and examine the string. That is the chief distinction between the two cases. No man of science, no one in fact "with a competent faculty of thinking," has ever supposed that in one case more than in the other *mere* difference of position was a form of energy.

It will be manifest from what we have said about Mr. Preston's work, that whatever value his own ideas respecting the ether may have, his corrections of the views he supposes to be accepted by men of science have no value whatever. He says "the present work is the result of much thought and careful study." He may have given much *thought* to it, but can scarcely have studied his subject very carefully. It is hardly to be expected that in a matter of such transcendent difficulty as he has selected for the subject of reflection, much can be accomplished without the most thorough investigation of at least all the verified phenomena, and no slight study of the researches and thoughts of the leading men of science who have dealt with the matter. We have seen how very little Mr. Preston appears to know about the theories of men of science. As to observed phenomena, his knowledge is very unequal. In some cases the facts he depends upon are correctly stated, in others they are doubtful, in others they are absolutely incorrect. As an instance of the last-named kind, we find at p. 130 the statement that the rate of transmission of electricity in materials of the greatest diversity is appreciably uniform—a circumstance which electricians will be a good deal surprised to learn.

We have given more space to Mr. Preston's work than its intrinsic value merits, because the erroneous ideas which he entertains respecting the accepted views of science about gravity, electricity, potential energy, and so forth, are very common. It is worth while to indicate, even at some expenditure of space, the views really entertained by men of science on this subject.

VIS INERTIÆ IN AIR AND OCEAN.*

MR. JORDAN'S last two works afford melancholy evidence of the fatuity of paradoxism. In volume vii. we had occasion, now some nine years since, to discuss his *Vis Inertiæ*, "a book nicely bound, well printed on good paper, abounding in maps, diagrams, and charts, yet—what Sterne would have called hobby-horsical." Nine years have not sufficed to show him how utterly without foundation is his system of the world, for like every true paradoxist, he proposes to run his hobby-horse full tilt at the centre of all things; and in the later of the two works now in our hands, announces his "System of the World," price one guinea. The basis of his system is easily explained. The solid earth turning on its axis from west to east leaves the water somewhat behind, which therefore has a relative motion towards the west. Hence the great equatorial currents. The air is left still more in the lurch, and thus has a westerly motion, even relatively to the water. Hence the trade winds. The planets nearest the sun are in like manner left behind in consequence of *vis inertiæ*. Hence they do not complete a circuit in the same time as the sun rotates. The remoter planets are left behind in greater degree, and hence the planetary periods grow longer and longer as the distances from the sun increase.

A reviewer unfamiliar with the ways of paradoxists might hope to indicate the error underlying this reasoning. For instance, he might hope to explain that even supposing that a solid earth could be set rotating within a fluid envelope at rest, this, which would at first lag, must eventually acquire the rotational movement in full degree, since otherwise an infinite effect would accrue from a finite cause; viz., never-ceasing friction from the original rotational impulse. And again, he might hope to show that what Mr. Jordan calls astral gravitation could not affect the fluid envelope without affecting in equal degree the solid mass within. Assuming him to possess the benevolence of a De Morgan, a reviewer might endeavour, even without hope, to explain a few of the elementary laws of physics to Mr. Jordan. We possess, however, neither hope to set a paradoxist right, nor infinite benevolence. Mr. Jordan's answer to any attempt to show that he does not rightly understand the laws of physics would simply be, as in his preface to "The Winds," "I rightly apprehend the fundamental principles of physics to be wrong." One point only do we care to controvert. He represents himself as in controversy with Dr. Carpenter and Professor Huxley respecting his theory of *vis inertiæ*. It is barely conceivable that a paper of Mr. Jordan's, read before the Geographical Society, was there and then replied to by Huxley. But we do not believe that there has been any subsequent controversy with Mr. Jordan; and we are quite certain that any discussion of his theory would be the most complete waste of time. No amount of reasoning would convince Mr. Jordan of its absurdity; nor can we conceive it possible that any besides himself has the least faith in it.

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* "The Winds and their Story of the World," and "Remarks on the recent Oceanic Explorations and the current-creating action of *vis inertiæ* in the Ocean." Both by W. L. Jordan, F.R.G.S. 8vo. London: Hardwicke and Bogue. 1877.

Certainly, if there are any such, reasoning would be thrown away upon them, What *they* would need would be to study the elementary laws of physics with care and patience for a few years, after which no reasoning would be wanted. But no one acquainted with the ways of paradoxists would think of recommending such a course to Mr. Jordan himself.

PHYSIOLOGICAL ÆSTHETICS.*

THE object of this work is to "elucidate physiologically the nature of our æsthetic feelings," to relegate the emotional to a purely physical origin, and to explain our conceptions of beauty relatively to pleasurable and painful feelings—the natural result of the action of an organism which is "a highly complex, but not absolutely perfect self-regulating machine"—"possessing the mysterious attributes of consciousness." The author, a man of much culture, writing in an admirable style, dedicates his book to "the greatest of living philosophers, Herbert Spencer" (by permission). Influenced by the tone and fashion of his master, Mr. Allen, a most enthusiastic disciple, fortunately writes clearly and nervously, and is often good enough to place the somewhat involved language of the great philosopher in plain and comprehensible English. He looks upon Herbert Spencer as Tait regards Sir William Thomson, and like him adds polish and facility of style to his "great one." Well instructed in the dominant physiology of the day, perfectly *au fait* with the modern development of the theory of the conservation of energy, and no mean student of art, the author has produced a book which is most readable and instructive; and doubtless as entertaining to the school to which he belongs as it is exasperating to those who think that there is inspiration in art and in the idea of beauty. As Herbert Spencer believes that in the progressing course of human modification under natural selection, sin will cease to be—so it follows from Mr. Allen that as years roll on, and a kind of art-pangenesis prevails and overcomes, the idea of the beautiful will become more fully evolved; and poetry, the drama, painting and sculpture will transcend modern description. Following up the same evolutionary notion, we must be impressed that ugly women will cease to be, and that by the time that the globe and the universe are to disappear in the Tyndallian azure, physical, moral, intellectual, and æsthetical perfection will have been arrived at. *Et puis?*

The author, wishing to examine the æsthetic feelings, and believing them to be intermediate between the bodily senses and the higher emotions, connects them with a physiological law of pleasure and pain. The feelings aroused in man by the beautiful in nature and human art are his subject matter, and he insists on their bearing a definite relation to pleasure and pain, and then of course to physical nervous change. Pain he decides to arise from severance, disruption, and disintegration of absolute nerve tissue; and pleasure to be "the concomitant of the healthy action of any or all of the organs or members supplied with different cerebro-spinal nerves *to an*

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* "Physiological Æsthetics." By George Allen, B.A. 8vo. London: Henry S. King & Co. 1877.

extent not exceeding the ordinary powers of reparation possessed by the system." Of course it is stated that pleasure and pain are the reflex of the actual state of the nerves, and that painful sensations may in their earlier stages be pleasurable and *vice versa.* Moreover, natural selection involves that "whatever is prejudicial or beneficial to the organism as a whole, is generally painful or pleasurable respectively to the separate organs which it is likely to affect. The healthy nutrition of our organs, if not relieved by functional activity; (and the same may be said of the tissues and muscles), leads to a tendency to exercise the superabundant energy in "play;" and when "we similarly exercise our eyes or ears, the resulting pleasure is called an æsthetic feeling." So "the æsthetically beautiful is that which affords the maximum of stimulation with the minimum of fatigue and waste in processes not directly connected with the vital functions. The æsthetically ugly is that which conspicuously fails to do so, which gives little stimulation, or makes excessive and wasteful demands upon certain portions of the organs. But as in either case the emotional element is weak, it is mainly recognized only as an intellectual discrimination. And so we get the idea of the æsthetic feelings as something noble and elevated, because they are not distinctly traceable to any life-serving function." The author has a capital chapter on taste, which he sums up with a very pertinent joke: "While it is true that *de gustibus non est disputandum*, it is eminently untrue that 'there's no accounting for tastes.'" Æsthetic education and the total effect of the æsthetic environment on happiness, are treated ably, and then the author passes on to the consideration of the lower senses in the concrete—taste, smell, feeling—and then those of higher import are noticed—hearing and seeing. A chapter on mental pleasures and pains is followed by one on the simulative arts and poetry. In treating of the influence of rhythm and sound in the enjoyment of poetry, the author notices how Milton and Tennyson achieve much success in "metrical technique;" and he remarks upon the influence of a change of the constituent part of a fixed metre in asserting the idea of imitation in the poet's work, quoting Tennyson—

> "The long brook falling through the cloven ravine,
> In *cataract after cataract* to the sea."

The work concludes with a practical answer to the question which must have arisen in the mind of every reader of this work: "Where, it will be asked, in such a system is there room for genius? If poetry consists of such special combinations of such special elements, why cannot any man sit down and write a great poem?" The author gives an admirable reply.

MACHINE DESIGN.*

ARBITRARY rules for the construction of machines are to be picked up in the drawing-office of almost any mechanical engineer. A work on machine design might, indeed, be easily compiled by stringing together a

* "The Elements of Machine Design: an Introduction to the Principles which determine the Arrangement and Proportion of the Parts of Machines and a Collection of Rules for Machine Design." By W. Cawthorne Unwin B.Sc., &c. London: Longmans. 1877.

number of these empirical dicta, with just sufficient explanatory matter to secure cohesion. Professor Unwin, however, as might have been expected, takes a much more lofty view of his subject, and while giving a collection of rules needful in the workshop, spares no pains to expose the theoretical aspect of machine construction. Between the man who works by mere rule of thumb and the man who follows scientific principles, there is of course all the difference in the world. As long as the same type of machine is being constructed, the old rules serve their purpose well enough; but let new materials or new forms of construction be introduced, and the mere "practical man" finds himself immediately at sea. It surely needs no mean amount of scientific knowledge to determine how the parts of a complex machine should be duly proportioned, so as to best resist the action of forces acting both from within and from without. Machine design has indeed been raised to the rank of a science, mainly by Redtenbacher; and in the work before us Professor Unwin has given an excellent compendium of the science in its present state.

Evidence of labour conscientiously spent in the preparation of this work is unquestionably stamped upon its pages. While the author clearly explains the art of machine design, he takes care also to explain the principles on which the art is based; and as a necessary consequence of this treatment his pages bristle with formulæ. Yet they are not in any wise formidable, and will present no difficulty to a student of ordinary intelligence. Scientific men might, perhaps, wish to see the metrical system of units introduced, but the old system here employed recommends itself by being familiar in all workshops. The work forms one of Messrs. Longmans' series of "Text-Books of Science," and falls well within the original aim of the series—that of providing especially for the needs of candidates for Whitworth Scholarships.

THE AMATEUR MECHANIC.*

WORKING with a lathe is so popular an amusement that Mr. Hobson's little book will, no doubt, be welcome to many an amateur. It gives us, in very plain language, a good deal of information about lathes and lathe-tools, drilling and planing machines, vices and other appendages to the bench; and it even touches upon the subject of brass-founding. As we read how to do this or that bit of work, we feel that we are being taught by one who has really handled the tools, and takes enthusiastic interest in his subject. Anyone attending to Mr. Hobson's teaching ought certainly to be able to construct for himself a model of a steam-engine; and, what is more than can be said of all home-made engines, when constructed it would probably work.

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* "The Amateur Mechanic's Practical Hand-book, describing the different Tools required in the Workshop, the Uses of them, and how to Use them; also Examples of different kinds of Work, with full Descriptions and Drawings." By Arthur H. G. Hobson. London: Longmans. 1877.

SHORT NOTICES.

*Mushrooms and Toadstools.**—We have never yet known a student of fungi who did not try to persuade his acquaintances to eat the objects of his study; and Mr. Worthington Smith is no exception to the rule. As his little book has reached a third edition, we may hope that he has found numerous proselytes; and we can safely recommend it as a guide not only to intending agaricophagists, if such a term be admissible, but also to all wanderers in country places who wish to learn something about the curious plants of which it treats. Mr. Smith notices and figures twenty-nine common species of edible mushrooms, and thirty-one poisonous forms.

Window Gardening.†—Mr. Mollison has produced an exceedingly elegant little manual for the guidance of all who desire to adorn their rooms with growing plants. He describes the management of plants in pots, window-boxes, and hanging frames; the different constructions of these articles best adapted for various purposes, the arrangement and management of Wardian cases, and the more ambitious window conservatories; notices the best plants for cultivation under various circumstances, and even descends from the balcony to the area, and gives directions for its adornment in a style which ought to earn him the gratitude of those worthy people of whose flirtations it is popularly supposed to be the scene. The little work is illustrated with coloured plates and numerous woodcuts.

The Morse Alphabet.‡—"Ce n'est que le premier pas qui coûte" is the motto of the anonymous author of a very little pamphlet which proposes to teach anyone the Morse alphabet in half an hour. This first step, at any rate, only costs fourpence. The idea is to represent the dots and dashes of the Morse alphabet by the syllables of words, the initial letter of which shall be the one represented by the combination. Thus "against" represents the - —— which stands for A. The author has been rather hard put to it to find suitable words, and in several cases he has not been successful, as may be understood from the fact that he has been compelled to make syllables short or long according as their vowel is followed by one or two consonants, without regard to pronunciation.

The Carbon Process.§—It is said that Michael Angelo, in obedience to a

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* "Mushrooms and Toadstools: how to Distinguish easily the Differences between Edible and Poisonous Fungi." By Worthington G. Smith, F.L.S. Third Edition, small 8vo. London: Hardwicke & Bogue. 1876.

† "The new Practical Window Gardener; being Practical Directions for the Cultivation of Flowering and Foliage Plants in Windows and Glazed Cases, and the Arrangement of Plants and Flowers for the Embellishment of the Household." By John R. Mollison. Small 8vo. London: Groombridge & Sons. 1877.

‡ "How to Learn the Morse Alphabet in Half an Hour." By the Author of "International Communication by Means of Numbers." Small 8vo. London: E. Marlborough & Co. 1876.

§ "Die Kohle-Druck und dessen Anwendung beim Vergrösserungs-Verfahren, nebst einer Notiz über Photomikrographie." Von Dr. Paul E. Liesegang. Fünfte Auflage. Düsseldorf: Phot. Archiv. Berlin: T. Grieben.

capricious command of Pietro de Medici, was at one time compelled to mould a statue in snow. Art in perishable material is always a thing to sigh over, and even if a photograph be not in every sense a work of art, it is nevertheless painful to see the beautiful sun-pictures slowly fade away. Permanence is what the photographer long struggled after, and what he at last secured by the carbon process. Of all the chemical elements carbon is perhaps the most stable; and the ink with which these lines are printed, having carbon for its basis, is well-nigh imperishable. Various processes have been introduced to the photographer for printing his pictures in media containing carbon, the germ of these processes being found in the remarkable effect of solar light on bichromate of potash in solution of gelatine. All the practical details of carbon-printing are clearly given by Dr. Liesegang in the neat little work before us, which forms one of the "Bibliothek für Photographen." We find, of course, a description of the author's method of producing enlarged carbon prints from small negatives. The work also contains much information on the production of permanent photographs for the magic lantern from small objects viewed under the microscope. So much attention is now paid in Germany to the magic-lantern as a means of scientific instruction, that a journal entitled the "Laterna Magica," edited by Dr. Liesegang, is now regularly issued at Düsseldorf.

*Dr. Tyndall's Electricity.**—To administer doses of science to juveniles home for their Christmas holidays is a task more difficult and delicate than some people may be willing to concede. Dr. Tyndall, however, is singularly successful in this work, and always contrives with rare tact to gild the scientific pill. The lectures on electricity in the work before us are admirable examples of the way in which experimental science may be effectively presented to boys and girls. All the experiments are ingeniously devised and inexpensively carried out. In fact the special feature of the work consists in showing how the leading principles of statical electricity may be demonstrated with simple apparatus of very homely type. Apples, potatoes, eggs, straws, tin-foil, glass tumblers—such are the familiar objects with which the greater number of the experiments are performed. It is often objected that physical science cannot be taught in schools in consequence of the expense of apparatus. Whilst admitting that there is something in this objection, it certainly loses half its force on a perusal of these lectures. Indeed, almost everything used in the experiments here described may be had for a five-pound note. And surely no school could object to so small an outlay for a course of lectures on electricity.

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* "Lessons in Electricity at the Royal Institution, 1875-6." By John Tyndall, LL.D., D.C.L., F.R.S. London: Longmans. 1876.

SCIENTIFIC SUMMARY.

ASTRONOMY.

WHAT are the Nebulæ?—A paper by Mr. Stone has recently been communicated to the Royal Society, in which he actually bases on Huggins's discovery of the bright line spectrum of certain nebulæ the theory that these are clusters of stars and not gaseous masses. His reasoning is remarkable. "The sun is known to be surrounded by a gaseous envelope of very considerable extent. Similar envelopes must surround the stars generally. Conceive a close stellar cluster. Each star, if isolated, would be surrounded by its own gaseous envelope. These gaseous envelopes might, in the case of a cluster, form over the whole, or a part of the cluster, a continuous mass of gas. So long as such a cluster was within a certain distance from us the light from the stellar masses would predominate over that of the gaseous envelopes. The spectrum would therefore be an ordinary stellar spectrum. Suppose such a cluster to be removed further and further from us; the light from each star would be diminished in the proportion of the inverse square of the distance; but such would not be the case with the light from the enveloping surface formed by the gaseous envelopes. The light from this envelope, received on a slit in the focus of an object-glass, would be sensibly constant, because the contributing area would be increased in the same proportion that the light from each part is diminished. The result would be that at some definite distance, and all greater distances, the preponderating light received from such a cluster would be derived from the gaseous envelopes and not from the isolated stellar masses. The spectrum of the cluster would therefore become a linear one, like that from the gaseous surroundings of our own sun." It seems hardly credible that a former first assistant at Greenwich and a mathematician of Mr. Stone's acknowledged power should reason in this wise. As shown in 1870, by Mr. Proctor, in a paper on resolvability as a test of distance ("Monthly Notices of the Roy. Astr. Soc." vol. xxx.), an irresolvable star-cluster would retain its intrinsic brightness unchanged, however its distance varied, so long as it continued irresolvable. For as the stars (separately undiscernible) became fainter with distance, the area over which they would be scattered would become smaller, and in the same degree. Dr. Huggins has thought it necessary to reply to Mr. Stone's paper! "Waiving the objections which may be urged against Mr. Stone's reasoning," he considers the results of observation. He points out (1) that there are not found in the spectra of different nebulæ the differences of relative brightness of the

bright lines and continuous spectrum, which would exist on Mr. Stone's hypothesis; (2) the star-clusters just within the resolving power of the largest telescopes do not give, even faintly, a spectrum of bright lines; and (3) the same bright lines appear to be common to all the nebulæ which give a bright-line spectrum, whereas on Mr. Stone's hypothesis, differences of constitution of the enclosing atmospheres of different star-groups would be probable. Towards the close of his reply, Dr. Huggins indicates the objection we have above enforced, and mentions that this objection was strongly insisted upon by Professor Stokes in remarks made when Mr. Stone's paper was read.

Supposition that Sunlight can be condensed.—Similar in incorrectness to the supposition that the brightness of an irresolvable stellar cluster can be diminished by distance, is the belief that under any circumstances sunlight (or other light from a luminous disc or surface) can be strengthened or condensed. It is singular that this mistake should have been fallen into by the present first assistant at Greenwich almost at the same time as the late first assistant enunciated the theory above discussed. A paper, too preposterous to be here dealt with, had been read before the Astronomical Society, suggesting that Venus has a metallic surface and a vitreous atmosphere. Referring to this paper, though of course rejecting the metallic surface and glass envelope, Mr. Christie pointed out that a mirror surface and an atmosphere capable of interior specular reflection, or the first alone with an ordinary refractive atmosphere, would explain the fact (?) that the arc of light seen round Venus in transit is brighter than the sun itself. Oddly enough a reply was made to this to the effect that a mirror surface was not needed for the purpose, but that ordinary refraction in the atmosphere of Venus would very much condense the sun's light, by compressing the whole disc of the sun into a fine arc of light around the outer limb of the planet. In point of fact, it is utterly impossible to condense light in this or any other way. As Mr. Proctor has shown, in a paper read before the June meeting of the Astronomical Society, by whatever process the breadth of the luminous surface is diminished (*i.e.* the axes of pencils proceeding from different parts of it brought nearer to parallelism), by the same process and to the same degree, the pencils themselves are made more divergent; thus a given portion of the retina receives pencils of light from a wider area of the sun's surface, but the quantity of light received from each pencil is in the same degree diminished. The arc of light seen round Venus was simply brighter than the neighbouring part of the sun's disc, because that light came from the whole of the sun, and the central part of the sun's disc is brighter than the part near the edge.

Distances of the Stars.—Mr. Stone, Astronomer-Royal at Cape Town, has gone over a portion of the evidence relative to the distribution of the fixed stars with respect to distance. It is singular that a matter so well-worn should still attract the attention of astronomers, more especially of official astronomers, whose duties in reality have no relation to such questions. "It may have been shown," says Mr. Stone, referring to Mr. Proctor's researches, "that some astronomers have attached undue importance to the numerical accuracy of the results obtained by W. Struve; but I cannot consider that the average distribution of stars according to apparent brightness has been,

or indeed ever will be, disproved. I do not know that there is much novelty in my views," &c. And then he proceeds to go over the old ground, very nearly along the old course, coming naturally to very nearly the same goal that W. Struve, Von Littrow, and others have reached. Mr. Stone's mathematical treatment of the portion of the evidence which he selects is of course perfectly sound; and if only that portion is considered, then unquestionably the conclusion at which he arrives must be regarded, not indeed as demonstrated, but as the conclusion which has in its favour the greatest weight of probability. But as there is a great deal of much weightier evidence, which he entirely omits to consider, and as that evidence is not merely opposed to the general conclusion at which Mr. Stone arrives, but demonstrates the incorrectness of that conclusion, the care and skill with which the imperfect evidence is dealt with, are in reality thrown away. Mr. Stone deals with the observed increase of numbers in stars down to Argeländer's ninth magnitude, comparing that increase with what would occur if stellar brightness depended in general on distance, stars being scattered with general uniformity throughout space; and he finds a general accordance between this theory and the observed facts, whence he deduces the conclusion that the theory is sound. But as it is certain that if the theory were sound there would be no real aggregations or rather segregations (in *space*) of stars of many orders of real magnitude, and as if there were no such aggregations there would certainly be no apparent aggregations of stars of many orders of apparent magnitude on the star-vault, it follows certainly that if such apparent aggregations exist, the theory of general uniformity of distribution is incorrect. It would not follow certainly, if no such aggregations existed, that the theory was sound, but it is certain that if they exist the theory is unsound. But it has been shown that they exist. They are made manifest to the eye in Mr. Proctor's equal-surface chart of 324,000 stars, where in some parts the stars are so closely set that there is barely room for them, minute though their discs are, while elsewhere they are strewn very sparsely—the regions rich in stars of the leading orders of apparent magnitude being those very portions of the Milky Way in which stars down to the twentieth magnitude are found in greatest numbers. The theory, then, of a general equality in the distribution of stars in space, even in the neighbouring parts of the system of stars, cannot be sound. As Mr. Proctor pointed out in a paper read at the May meeting of the Astronomical Society, if a surveyor were to urge against a theory respecting certain mounds that the mounds have in reality no existence, seeing that, if they were levelled, the general level of the ground would be very nearly the same as though the mounds had not been there—his arguments would not be thought to have much weight. Mr. Stone's theory (sound though its mathematical portion is) is of a similar kind. It is simply a demonstration of the fact that if we leave out of consideration the aggregations of stars on the star vault, these aggregations no longer afford any evidence of the real aggregation of stars in space.

Approaching Opposition of Mars.—Dr. Terby, of Louvain, who has devoted much attention to the subject of the charting of Mars, calls attention to the questions which he has raised in his memoir on the subject. These questions are quoted elsewhere in the present number. He begs astronomers to com-

municate their observations to him, to enable him to perfect Mr. Proctor's chart of the planet.

The Astronomer-Royal has also invited attention to observations in connection with the determination of the solar parallax, which might advantageously be made at the approaching opposition of Mars. He cited, from the "Monthly Notices" of 1857, his paper "On the means available for correcting our measures of the sun's distance during the next twenty-five years," in which, alluding to Flamsteed's method by observing the displacement of Mars in right ascension when he is far east and far west of the meridian, and pointing out its facilities, he had concluded that this method is the best of all. "An unexpected opportunity," he continued, "of obtaining observations, probably of a much superior class, has presented itself. Lord Lindsay is willing to lend his heliometer; and Mr. Gill, who has had extensive experience in the use of that instrument, and is perfectly acquainted with its adjustments of all kinds, offers his own time and labour at St. Helena or Ascension." He then referred to the probable expenses of the expedition. Since then, the sum necessary (500*l.*) has been granted by the Astronomical Society, one-half to be eventually repaid, either from the Government allowance to the Royal Society, or by Lord Lindsay and Messrs. De la Rue and Spottiswoode. The place since selected by Mr. Gill is the Island of Ascension, where the weather is likely to be more suitable than at the Mauritius. A rigid determination of the planet's heliocentric position will be among the objects of Mr. Gill's observations.

The Total Eclipse of the Moon last February.—Mr. Penrose remarks that during totality the northern and southern parts of the moon appeared very much brighter than the eastern and western parts; adding that this "presumably arose from some interference with the light refracted through the earth's atmosphere, from a greater prevalence of clouds in the equatorial regions than at the two poles; some amount of specular reflection, at very flat angles from the northern and southern ice, may also have aided in producing this effect." Mr. Penrose is so thorough a master of the geometry of eclipses, and so well able to calculate the amount of light falling upon various parts of the moon from the irregular ring of light which must appear to surround the earth as supposed to be seen during totality from the moon, that we cannot doubt the above sentence was penned without much thought; for it is certain that the light from various parts of that irregular ring is mingled and in nearly equal proportions over all parts of the moon's eclipsed hemisphere, not distributed locally. The mistake of attributing the different degrees of light on various parts of the eclipsed moon to this cause is as old as Wargentin, if not older. Probably Mr. Penrose had noted it in some of the older descriptions of eclipses without perceiving that it is erroneous; and naturally enough quoted it, without remembering that he had not closely examined it.

Rev. Fr. Perry remarks that the thin circle of light on the moon's limb was in such striking contrast with the cloudy dull brick-red shading of the centre that to many persons it seemed as if the moon was not completely immersed in the earth's shadow. Fr. Perry and Mr. Penrose formed, by the way, entirely different views respecting the definiteness of the umbra's outline. Fr. Perry says, "the darkness of that portion of the penumbra which

was in close proximity to the umbra was so great that the last contact was difficult to observe." Mr. Penrose found, however, that even simultaneous unaided eye-observations of the beginning and end of totality did not differ by many seconds.

Opposition of Ariadne.—The minor planet Ariadne (43) is in opposition on July 24, in circumstances very favourable for determining its diurnal parallax by the heliocentric method. The distance of the planet from the earth is 0·83, the sun's mean distance from the earth being taken as unity. Mr. Gill proposes to observe this planet with the heliometer during his stay at Ascension, where the observations will be made under very favourable conditions. Opposition will occur ten days before he can begin to observe Mars satisfactorily. The observations can therefore be made without inconvenience or additional expense. "It is true," says Mr. Gill, "the planet is somewhat faint (8·8 mag.), but experience at Mauritius has taught me that with such a heliometer as Lord Lindsay's, in a tropical sky, 8·5 mag. stars can be measured with more accuracy than any other, and that ninth mag. stars can be well measured in favourable atmospheric conditions. The geometrical conditions are very much more favourable than in the case of Juno (whose distance at opposition was 1·05); and besides it is possible to select more suitable stars of comparison . . . The opposition of Iris (7) and Melpomene (18) are also very favourable."

The Planet Vulcan.—It is hardly necessary to say that the transit of Vulcan, expected by Leverrier on March 22 (or 21 or 23), was not observed either in the northern or the southern hemisphere.

The Great Meteor of March 17 last.—Captain Tupman has collected together various observations of this meteor, as seen at Frome, Cambridge, Kensington, Gunnersbury, Tetbury, Rossall, and Brighton. From these he has deduced the following inferences:—

The radiant must have been very near R.A. 145°, N.P.D. 95°, at an altitude of 35°. The meteor first became visible 60 miles over 50° 59′ N., 3° 4′ W. (or nearly over Taunton). The point of disappearance was about 39 miles above 5° 41′ N., 3° 4′ W. (near Pontypool). This path satisfies all the descriptions within ordinary errors of observation. The length of the path was about 59 statute miles. The duration was given as certainly about 3s., by Mr. Homer; 4s. or 5s., by Mr. Hollis; 3s., by Mr. Ballard, at Banbury; and 2s., by another observer. The mean of these is 3·1s., giving a relative velocity of 19 miles per second. From the radiant point given above the following parabolic elements of the orbit are deduced:—

Rising node	177°·4
Inclination	8·5
Longitude of perihelion	222·5
Perihelion distance	0·850
Motion	*Direct.*

Whence the relative velocity is 33·3 statute miles per second, and the total duration 4½ seconds. It follows, then (though Captain Tupman makes no reference to the point), that, if the duration was rightly observed, the real path of the meteor was hyperbolic.

During the first half of its track the meteor was like burning magnesium

in appearance, then the colour became red, and lastly was vivid green. All along its track fiery ashes fell towards the earth, and after the extinction of the principal part, a body of dark-red sparks continued to fall for a short distance, as seen by Mr. Davis, at Tetbury. Lady Portsmouth, driving near Basingstoke, 90 miles from the meteor, and facing west, "was startled by what appeared to be blue or bluish-green lights falling apparently in large flakes into a field on her left. Some seconds after, while the whole country was lighted up as if by the brightest possible lightning, a large red ball was seen travelling with comparative slowness on the right over a field, into which it appeared to fall." From Waterford the meteor was seen to be double, one part closely following the other. This duplicity is not reported from any other place. The meteor left little or no streak, and did not detonate, for several of the observers state that they listened for any noise.

Captain Tupman mentions as a curious instance of inaccuracy that a certain person writing over the signature "J. M. W." in the "Times," describes the meteor "as two-thirds of the size of the moon *when overhead.*" At first this was supposed to mean that the meteor, when overhead, so appeared; and Captain Tupman noted that the meteor was never in reality within 65° of the zenith of London. But it was explained that "J. M. W." meant that the meteor was two-thirds of the size of the moon when she is overhead—a curious double error, seeing that the moon never is overhead in London, and that her size when at her highest is not different, so far as ordinary naked eye observation is concerned, from her size when near the horizon. But how can the general public be expected to be accurate when we find in a text-book of astronomy, by a well-known author, such blunders as the statement that the stars which pass overhead in London rise and set on a slant—the truth being that they never come within 13° of the horizon?

New Comets.—On April 6, Professor Winnecke, of the Imperial Observatory at Strasburg, announced the discovery of a new and rather bright comet. He soon after published the following elements, side by side with which we set Hind's later and doubtless more correct result:—

Perihelion Passage	Winnecke, April 18·1741 (Berlin Time)	Hind. April 17·64887 (G.M.T.)
Longitude of perihelion	251° 59′ 57″	253° 30′ 9″
Ascending node	317° 51′ 18″	316° 33′ 53″
Inclination	56° 42′ 42″	58° 54′ 22′
Perihelion	0·92824	0·950250
Motion	Retrograde	Retrograde

Another new comet, much fainter, was discovered by M. Borelly, on the evening of April 14, in R.A. 16° 31′; N.P.D. 34° 56′; daily motion in R.A. +120′, in N.P.D. −50′.

Phenomena for the Quarter.—Jupiter, which was in opposition on June 19, will reach his second station on Aug. 20, and quadrature on Sept. 17. Mars will pass his first station on Aug. 17, perihelion on Aug. 21, and be in opposition on Sept. 5, midnight. Saturn will be in opposition on Sept. 9, two P.M. Neptune on quadrature on July 30, and stationary Aug. 10, will thence pass to opposition on Oct. 28.

BOTANY.

On the Trees and Shrubs of the South of France which Perish in Severe Winters.—M. C. Martins has communicated to the Academy of Sciences ("Comptes rendus," March 19, 1877, p. 534), a paper on the indigenous trees and shrubs of the South of France which suffer from frost in exceptionally severe winters, in which he attempts to demonstrate their relationship to the former flora of this part of France. These plants are as follows, arranged in the order of their sensibility to cold:—*Ceratonia siliqua, Euphorbia dendroides, Ostrya carpinifolia, Nerium Oleander, Chamærops humilis, Myrtus communis, Anthyllis barba-jovis, Laurus nobilis, Anagyris fœtida, Punica granatum, Olea europæa, Ficus carica, Coriaria myrtifolia, Smilax aspera, Pistachia lentiscus, Viburnum tinus, Quercus Ilex, Cistus monspeliensis,* and *Vitis vinifera.*

M. Martins remarks that these plants are all more or less of exotic types. Some of them are the sole European representatives of certain groups, families, tribes, or genera of plants. *Anthyllis barba-jovis, Pistachia lentiscus, Viburnum tinus, Quercus Ilex,* and *Cistus monspeliensis* alone form parts of families which possess other European genera or species. Most of them are of rare and local occurrence, only flourishing in exceptionally sheltered places, having the climate warmer, both in summer and winter, than open spots exposed to all winds. The *Pistachia,* the *Cistus,* the *Smilax,* and the Evergreen Oak are the only ones common throughout the Mediterranean littoral zone of France. *Vibernum tinus* and *Anagyris fœtida* flower in the middle of winter.

All these peculiarities M. Martins thinks may be easily explained by assuming that these plants are survivors from the flora which covered the soil of Southern France during the Tertiary period. The vegetation of that period, as revealed by its fossil remains, indicates a much warmer climate than now prevails in the littoral zone, and most of the species which scarcely differ from those now living are found in the lacustrine deposits of the region itself, and have been for the most part described by Count Saporta. Of *Ceratonia* five fossil species are described; one, the *Ceratonia siliqua,* has survived the climatic changes which have occurred since the Miocene, and especially the Glacial epoch. Its most probable ancestor is *C. vetusta,* Sap., from the gypsum of Aix. The common Myrtle is the descendant of *Myrtus atava,* Sap., of the Miocene calcareous slates of Armissan, near Narbonne, and it has been found fossil in the volcanic deposits of Saint-Jorge, in Madeira, by Professor Heer. The Oleander (*Nerium Oleander*) passed through the whole Tertiary period. It occurs in the Eocene of the Sarthe, and in the Miocene of Oropo, in Attica, and its form, *N. Gaudrianum,* Ad. Brongn., is intermediate between *N. Oleander* and *N. odorum.* Thus the fossil species has split into two living species. Thirty fossil species of Laurels are known; one, *Laurus nobilis,* is still living in the region, and it existed during the lower Pliocene epoch, as it occurs in the tufs of Meximieux. Nearly-allied species, *L. canariensis,* Webb, and *L. fœtens,* Ait. (*Oreodaphne fœtens,* Nees), descending from *Oreodaphne Heerii,* Gaud., of the Tuscan Quaternary deposits, have maintained themselves in the Canaries, the insular climate of

which approaches nearer than that of the South of France to the climate of the Tertiary periods.

In his memoir M. Martins shows, in like manner, that most of the tender trees and shrubs of the South of France have their fossil ancestors in Tertiary or Quaternary strata, formed at an epoch when the climate of Europe was so warm that many plants inhabited countries where they could not now pass a single winter. He instances the occurrence of *Chamærops humilis* in the north of Switzerland, of the Oleander in the Sarthe, of the Pomegranate in the neighbourhood of Lyons, and of the Vine in Silesia. This note of M. Martins' is an interesting contribution to the confirmation and extension of results already obtained by various palæontologists, especially Heer and Ettingshausen, as to the filiation of the existing flora to that of Tertiary times.

CHEMISTRY.

The Absorption-Spectrum of Potassium Permanganate, and Volumetric Analysis.—While concentrated solutions of this salt exhibit a broad absorption band which blots out all the green and a part of the blue of the spectrum, the same liquid, when rendered very dilute, is recognized in the spectroscope by the presence of five distinct and separate lines or bands, the first of which is near D, the last at F, and the middle one of all between E and *b*; the first and last are considerably less dark than the others. These bands are readily distinguished, even after often-repeated dilution, and the second and third of them, which are the last to disappear, can be perceived almost as long as the liquid itself shows a reddish tint. In the performance of volumetric analyses of colourless solutions the point where the fine colour of permanganate ceases to be destroyed is readily determined; if the liquid under examination, however, has a distinct colour which renders the reaction obscure to the eye, the exact stage when an excess of permanganate is added may be found by aid of the spectroscope. Brücke, who has devised this useful means of giving increased accuracy to several analytical processes in which permanganate is employed, makes use of a direct-vision spectroscope by Steinheil; he explains, moreover, in his paper, how observations can be made with a common prism of 60°. In the case where it is desired to determine quantitatively a comparatively small amount of iron protoxide in the presence of iron oxide, the degree to which the solution can be diluted is limited, lest the error of observation become too great. An excess of permanganate, however, may be added to the yellow solution, which shall so little affect the tint of the liquid that it cannot be distinguished from a simple concentrated solution of the higher oxide. An observation with the spectroscope will then indicate the presence of the characteristic absorption lines of the manganese salt, and solution of a salt of iron protoxide of known strength can then be added till they disappear; and thus the necessary correction can be made. It is pointed out by the author that this method, which can be employed with complete success by such persons as are colour-blind, may be made use of in the case of solutions of any degree of concentration or dilution. There is a method for the volumetric determina-

tion of iodine when in combination, proposed by Hempel and described by Mohr in his "Lehrbuch der Titrirmethode," which under certain conditions cannot be carried out with the desired precision, from the fact of the liberated iodine giving a violet tint to the liquid. Brücke shows how his method can be advantageously made use of in this case. If any salts of cobalt happen to be present in a solution in which the amount of a constituent is to be determined by means of permanganate, their pink colour so closely resembles that of the diluted reagent that the point when oxidation is effected is difficult to arrive at; the use of the spectroscope, however, enables the operator to detect the moment when the reaction is complete. A pale red solution of a cobalt salt was prepared, and a portion diluted with water; permanganate was then added to it till the tint closely resembled that of the other portion, except that the colour was very slightly more violet; when placed before the spectroscope the difference was very marked, all the five lines being readily seen. —*Journal für praktische Chemie*, lxxxviii., 486.

Neptunium.—During the last seventeen years the beautiful method of spectrum analysis has been the means of identifying five new elementary bodies: cæsium, rubidium, thallium, indium, and gallium. It is with no little interest that we find that the existence of another element, in this case also a metal, has been detected by the old and more difficult method of mineral analysis. Hermann, who published his first paper on minerals containing metals of the tantalum group a third of a century ago, has found a new metal, which he has named neptunium, in a specimem of "tantalite" from Haddam, in Connecticut. His examination has shown the specimen to be not a mineral species, but a mixture of about equal amounts of columbite and ferro-ilmenite, both of which minerals occur in the granite of Haddam. The metallic acids contained in this specimen are present in the following proportions:—

$Ta_2 O_5$ . . .	=	32·39
$Nb_4 O_7$ . . .	=	36·79
$Il_4 O_7$ . . .	=	24·52
$Np_4 O_7$ . . .	=	6·30
		100·00

The method adopted in separating the oxide of the new body rests on the inferior solubility of its soda-salt in boiling water. Neptunium appears to exhibit all the more important properties of the metals of the tantalum group, and evidently finds a place amongst them. From niobium and ilmenium it is distinguished by the fact of its fluoride forming with soda an amorphous insoluble precipitate; the other metals give crystalline precipitates, which dissolve in twenty-five parts of boiling water. It can be separated from tantalum by the property which its fluoride possesses of forming with potassium fluoride a salt which is easily soluble, the corresponding double compound of tantalum requiring 200 parts of water at 10° C. for its solution. The soda-salt of the new element colours a bead of microcosmic salt golden-yellow, while the other metals comport themselves under similar circumstances in the following characteristic manner: tantalum,

colourless; niobium, blue; and ilmenium, brown. Hermann refers to other reactions which serve to identify it. He has determined the atomic weight of neptunium by an analysis of the neptunium-potassium fluoride ($4\ K\ Fl + Np_2\ Fl_7 + 2\ H_2\ 0$) and finds it to be 118·2. The combining numbers of the metals of this group form the following series:—

Tantalum	176·
Neptunium	118·2
Niobium	114·2
Ilmenium	104·6

The metal itself has not yet been prepared, the author having at present only forty grains of the hydrate of the metallic acid for investigation. Assuming, however, that neptunic acid ($Np_4\ 0_7$), obtained by igniting the hydrate, is similarly constituted to the corresponding oxide of niobium, he calculates its specific gravity and atomic volume. He finds the density of neptunium to be 6·55, and the atomic volumes of the metals of this group form the following series:—

Tantalum	= 16·5
Niobium 16·5 + (1 × 0·5) .	= 17·0
Ilmenium 16·5 + (2 × 0·5) .	= 17·5
Neptunium 16·5 + (3 × 0·5) .	= 18·0

While the precipitate formed on the addition of soda to the fluoride of the new metal is, as has been stated, insoluble, neptunic acid when fused with soda and treated with boiling water dissolves in that menstruum, and prismatic crystals separate from the liquid as it cools. Tantalum, on the other hand, when similarly treated, deposits crystals which have the form of hexagonal plates.—*Journal für praktische Chemie*, 1877, xv., 105.

Trimethylamine.—Vincent directs attention to the value of this compound in analysis. After describing the mode of preparation he refers to some of its reactions which differ in many important respects from those of ammonia. With trimethylamine the salts of aluminium form white gelatinous precipitates which dissolve in an excess of the reagent. The salts of cobalt, nickel, copper and zinc form precipitates which do not disappear on the addition of a large excess of trimethylamine. The salt of silver forms a dull grey-coloured precipitate which dissolves in a large excess of the compound ammonia; the chloride of this metal, on the other hand, appears to be quite insoluble in trimethylamine. A substance which exhibits reactions so strongly contrasted with those of ammonia cannot fail to be of great use in special branches of practical chemistry.—*Bull. Soc. Chimie, Paris.*, xxvii., 194.

The Chemical Composition of the Flesh of the Halibut.—The halibut (*Hippoglossus americanus*, Gill), which abounds in the waters of the Atlantic, as far north as Newfoundland and as far south at Cape Hatteras, is highly valued as food in the United States. The flesh is of a fine white colour, is delicate and tender, and resembles that of the whiting (*Merlangus vulgaris*). The fresh flesh of the halibut has been analysed by Chittenden, and he gives in his paper the results of his examination side by side with those of

Payen, who investigated the composition of the flesh of the whiting. They are as follow:—

	Halibut.	Whiting.
Water	82·87	82·95
Solid constituents	17·12	17·05
Ash	1·08	1·08
Fatty matter	1·26	0·38
Nitrogen	2·01	2·41

The flesh of the American fish, when dried at 100° C., was found to consist of—

Carbon	50·38
Hydrogen	7·43
Nitrogen	11·68
Oxygen	6·35
Ash	24·16
	100·00

and of the above constituents 7·11 per cent. were present in the form of fatty matter. The ash of the flesh of this fish is composed of—

Silicic acid	0·32
Chlorine	11·11
Carbonic acid	1·13
Sulphuric acid	1·30
Phosphoric acid	34·36
Iron	0·19
Lime	0·15
Magnesia	2·43
Potash	37·07
Soda	12·22
Lithia	trace.
	100·28

Some considerable part of the alkaline metals which the author gives as oxides in the above percentage numbers must in reality be present in the form of *chlorides*, combined with the 11·11 per cent. of chlorine, and the total constituents found must therefore fall short of the total above given. In fact, the 11·11 per cent. of chlorine has, so to speak, been left out in the cold, uncombined, and must take the place of oxygen in these calculated results; this will reduce the total considerably. More than 70 per cent. of the constituents of the ash, according to the author's mode of regarding them, consists of phosphoric acid and potash.—*American Journal of Science*, 1877, x., 111–123.

The Estimation of Nitrogen in Nitrates.—The method recommended by Thorpe in his *Quantitative Chemical Analysis* for the determination of nitrogen in nitrates, has been examined by S. W. Johnson, of Yale College. The plan referred to consists in reducing compounds containing nitric acid to the form of ammonia by the use of strips of zinc covered with copper, by the "couple," in short, devised by Gladstone and Tribe. The author

gathers from Thorpe's paper that "the results are such as apparently establish its great exactness, while in simplicity and ease of execution it would seem to be quite superior to the similar methods which have been previously proposed." The first determination which Johnson made by Thorpe's process showed a deficiency of 45 per cent. In a second experiment nitric oxide was evolved, "the standard acid not only not being neutralized by ammonia, coming from reduction, but made more acid by the reaction of nitric oxide upon the oxygen and water of the condensing vessels." In the third and fourth experiments the results were equally unsatisfactory. The author then made three determinations by Bunsen's method with zinc-iron couples and caustic potash, and obtained concordant and perfectly satisfactory results, the numbers, it should be stated, being uniformly 0·3 to 0·6 per cent. under that required by theory.—*American Journal of Science*, April, 1877, xiii., 260.

The Protection of Iron against Rust.—A most important method has been devised by Professor Barff for preserving iron from rust. As far as we are able to judge from the results of the experiments which have thus far been made, the process is one of manifold application, and bids fair to prove of the greatest service in many branches of industry. Professor Barff has discovered a means of rendering all kinds of ironwork, however much exposed to the weather or to corrosive vapours and liquids, practically indestructible and permanent. Iron when exposed to the action of water or moist air begins to rust, a film of ferrous oxide being in the first instance formed upon its surface; this rapidly takes up more oxygen from the air, and a higher oxide, the sesquioxide, is formed; the latter compound gives up some of the oxygen to the unchanged metal beneath it, and the fresh ferrous oxide thus produced slowly unites with more oxygen, which traverses the porous layer of sesquioxide overlying it; in this manner the change is propagated to greater and greater depths, until in process of time the whole of the metal may be converted into rust. Various methods are employed to check this oxidation; paints and varnishes are used with, however, only partial success, from the fact that the adhesion of those materials to the metallic surface is imperfect, and they are liable to scale off and disintegrate with changes of temperature. Professor Barff proposes as a remedy the covering of the face of the metal with a layer of the oxide of iron, intermediate in composition between the two compounds we have above alluded to, the ferroso-ferric or magnetic oxide; and this he accomplishes by exposing the metal to the action of superheated steam at a high temperature. Iron treated in this manner for from six to seven hours at 1200° F. becomes covered with a black film of magnetic oxide, which adheres to it even more firmly than the metallic particles adhere to each other, and is sufficiently hard to resist the action of a file. At his lecture delivered before the Society of Arts, and subsequently at a soirée held in the Royal Society's rooms, Professor Barff showed specimens, treated by his method, which had passed unscathed through a six weeks' exposure to bad weather on a lawn in Bayswater, as well as others which had been lying in contact with corrosive liquids of every kind in the sink of a laboratory. It is easy to conceive of applications being made of Professor Barff's method which may prove of the greatest value and importance. Among many which have been suggested are the

protection of the plates of steam-boilers and of iron ships, the use of iron saucepans in place of tinned vessels, iron for many domestic purposes replacing the more costly copper; and we may, moreover, look forward to the time when leaden pipes for the conveyance of water will be entirely superseded. Again, there is every reason to suppose that this new process possesses many advantages over "galvanizing" applied to materials made of iron.

Succinic Acid in the Juice of the Unripe Grape.—During an examination of the juice of the unripe grape, conducted by Brunner and Brandenburg, with the hope of detecting as constituents glyoxylic acid and desoxalic acid, these observers recognized the presence in considerable quantity of succinic acid. The expressed juice of fruit, gathered in the middle of June, formed the material. After treatment with lime carbonate, and the removal of protein compounds by raising the liquid to the boiling point, the filtered liquid was concentrated and further purified with animal charcoal; a crystalline body was at length obtained, which proved on analysis to be calcium succinate. The acids sought for were not met with, and this failure to detect them is ascribed to the possibility of the grape having reached to an advanced stage of its development; the authors therefore intend to repeat their experiments with fruit at a still earlier period immediately after flowering. If they succeed in proving glyoxylic acid to be a normal constituent of the plant, a conception of the gradual conversion of carbonic acid into the vegetable acids under the reducing action of light may be arrived at —a metamorphosis in harmony with reactions which can be performed in the laboratory. The acids referred to, as well as others met with in vegetable tissues, might then be regarded as successively derived from a hypothetical carbonic hydrate by the following stages of reduction :—

$$2(CH_2O_3) + H_2 = \underset{\text{oxalic acid}}{C_2H_2O_4} + 2H_2O$$

$$C_2H_2O_4 + H_2 = \underset{\text{glyoxylic acid}}{C_2H_2O_3} + H_2O$$

$$C_2H_2O_3 + H_2 = \underset{\text{glycollic acid}}{C_2H_4O_3}$$

$$2(C_2H_2O_3) + H_2 = \underset{\text{tartaric acid}}{C_4H_6O_6}$$

$$C_4H_6O_6 + H_2 = \underset{\text{malic acid}}{C_4H_6O_5} + H_2O$$

$$C_4H_6O_5 + H_2 = \underset{\text{succinic acid}}{C_4H_6O_4} + H_2O$$

Oxalic acid is present in the leaves of the vine, according to Neubauer, who found it to be abundantly present, as well as some malic acid, in the wines of inferior vintages like that of 1871. Malic acid is not met with in wines of good vintage, although it occurs plentifully in the leaf of the vine at a certain stage of its growth. Neubauer also found succinic acid in the spring sap of the vine, and Gorup-Besanez detected the presence of glycollic acid and malic acid in the leaves of the Virginian creeper.—*Zeitschrift für analytische Chemie*, 1877, xvi., 246.

Nucite.—Tanret and Villiers have isolated and analysed a crystallizable sugar which occurs in the leaf of the walnut. It crystallizes in clinorhombic prisms

which have the specific gravity 1·54 at 10° C., and melt at 208° C. This body, which has been found on analysis to have the composition indicated by the formula $C_6H_{12}O_6 + 2H_2O$, does not reduce an alcoholic solution of a copper salt, and cannot be fermented. When oxidized with nitric acid it does not yield muric or oxalic acid, but forms a new body, the properties of which have not yet been investigated. Nucite, the name which the authors have given to this variety of sugar, is a body which closely resembles inosite in its characters.—*Comptes rendus*, Feb. 26, 1877.

GEOLOGY AND PALÆONTOLOGY.

The Mosasauridæ.—Professor Owen lately read a paper before the Geological Society, on the rank and affinities of the Mosasaurians, that curious family of Reptiles, the remains of which were originally discovered in St. Peter's Mount, near Maestricht. The Maestricht species was referred to the Cetacea by the great anatomist Campu, and to the Crocodilia by Faujas de St. Fond, whilst Cuvier regarded it as a true Lizard. Lately numerous remains of similar animals have been found in the Cretaceous rocks of America, and in examining these Professor Cope was led to recognize in them certain affinities to the Serpents; he spoke of them as "veritable sea-serpents," and formed them into an order which he called Pythonomorpha, in allusion to its supposed Ophidian characters. Professor Owen discussed in detail the various characters presented by the remains of these animals, and from his examination of these drew the following conclusions:—In the single occipital condyle and the composite structure of the mandible the Mosasaurians are Reptilian, as also in their procœlian vertebræ; in the double occipital hypapophyses, the bifurcate and perforate parietal, the presence of the "columella," the composite formation of the suspensory joint of the tympanic and in the type of the tympanic, the frame of the parial nostrils and the structure and attachment of the teeth, they are Lacertian. In one special dental modification they are Iguanian, in another Monitorial, and their special group characters consist in the more extensive fixation of the pterygoids and ossification of the roof of the mouth, the large proportion of the vertebral column devoid of zygapophyses, the confluence of the hæmal arch with the centrum in certain of the caudal vertebræ, and the natatory character of the fore and hind limbs. These distinctive characters did not appear to the author to be sufficient for ordinal rank, and with Professor Gervais he regarded the Mosasauridæ as a family of Lacertilia, equivalent to the Iguanodontidæ and Megalosauridæ in the order Dinosauria. The order Lacertilia among Reptiles, being equivalent to the order Carnivora or Feræ among Mammals, the Mosasaurians would be the equivalent of the Seals in the latter.

Hyænarctos in England.—In 1836 Messrs. Falconer and Cautley described a fossil from the Sewalik Tertiaries under the name of *Ursus sivalensis*, regarding it as a true Bear. In 1837 Wagner recognized its distinctness from the true *Ursi*, and established a genus for it under the name of *Agriotherium*, whilst in 1841 De Blainville gave no less than two names to the genus,

namely, *Amphiarctos* and *Sivalarctos*. This fortunate fossil had thus at least three generic names appropriated to it; but this was not enough. At some later but uncertain date the original describers of the species proposed for it the name of *Hyænarctos*, which has been adopted to the exclusion of all the others. Of late years examples of the genus have been found far from the original habitat, namely, in the Pliocene marine sands of Montpellier (*Hyænarctos insignis*), and in Miocene deposits at Sansans (*H. hemicyon*), and at Alcoy, in Spain. The range of this Sewalik form is now shown to be still wider by the discovery of two upper molar teeth, which are undistinguishable from the corresponding teeth of *Hyænarctos sivalensis*, in the Red Crag deposits of Waldringfield, Suffolk. These were lately described by Professor Flower, in a paper read to the Geological Society.

Ichthyosauri in the Rhætic Beds of the Saone-et-Loire.—M. H. E. Sauvage notices the occurrence of remains of animals of the genus *Ichthyosaurus* in the Rhætic beds of Antilly and le Coudre, in the department of the Saone-et-Loire. He refers the specimens found to two species, which he names *Ichthyosaurus rheticus and I. carinatus*. In the former the vertebræ of the middle portion of the dorsal region are strongly biconcave; their longitudinal diameter is two-fifths of the transverse or vertical diameter, and their lower surface is flattened. The dorsal vertebræ of *I. carinatus* are more disclike, their longitudinal diameter being only two-sevenths of their transverse diameter; and the lower surface has a median keel, on each side of which there is a deep impression. M. Sauvage gives no indication of the size of these vertebræ.—*Ann. Sci. Géol.*, tome vii.

Veins of Bitumen in Granite.—M. A. Julien records the occurrence, in the granite of the neighbourhood of Clermont-Ferrand, of distinct bituminous veins. They are found in a railway cutting between Royat-les-Bains and Votrie, where they form a sort of network. The bituminous substance is sometimes black and soft. In other places it is a solid, brilliant asphalte, with a resinous lustre, a conchoidal fracture, and a brownish or blackish-brown colour, and forms veins varying in thickness from two or three lines to two or three centimètres. At the first glance it might be taken for brown flint, but it fuses at the temperature of boiling water, and burns with a clear flame, producing a strong and characteristic odour.—*Comptes rendus*, April 9, 1877.

Diffusion of Strontian in Nature.—M. Dieulafait, in a memoir presented to the French Academy of Sciences ("Comptes Rendus," June, 1877), gives the results of his investigations upon this subject, which are of interest in themselves and as bearing upon the general question of the mode of occurrence in nature of comparatively rare substances. His experiments appear to have been carried on chiefly by means of the spectroscope.

M. Dieulafait finds that strontian exists in sea-water as carbonate and sulphate. In the former state it may be recognized in 100, in the latter in 4 cubic centimètres of water. The gypsum formed in salt marshes before the deposition of salt contains strontian in such quantity that 1 milligramme of the substance distinctly gives its spectrum; and as in the evaporation of sea-water the strontian is always thrown down in the precipitates of carbonate and sulphate of lime which are first produced, it is naturally missing in the sodium chloride and other salts afterwards produced. As strontian is always associated with the carbonate and sulphate of lime dissolved in

sea-water, it ought also to occur in the hard parts of marine organisms consisting of those salts; and M. Dieulafait has always found it in them with a weight of not more than 1 centigramme. A further investigation showed that this rule applied also to the fossil remains of organisms, for 120 species of Brachiopoda, from the whole series of formations from the Silurian upwards, all furnished the spectrum of strontian with quantities of substance less than 1 centigramme. In the author's opinion all deposits of gypsum, of whatever geological age, have been produced simply by the evaporation of sea-water at the ordinary temperature of each epoch; and if this view be correct, and the seas of all times had the same constitution all specimens of gypsum ought to contain strontian. This was found to be the case in 188 samples of Triassic gypsum, 85 of Tertiary gypsum, 4 of gypsum with mica (so-called metamorphic gypsum), and 6 specimens of the ophitic deposits of the Pyrenees, and the strontian was found to be pretty uniformly diffused throughout the mass of each deposit. In mineral waters also, as might be expected, strontian is at least very generally present in variable quantities.

MINERALOGY.

Heubachite.—Sandberger has given this name to a mixture of the hydrated oxides of cobalt and nickel (with a little iron and manganese oxide) which occurs in black flakes and occasional spherular forms, on the heavy spar of the St. Anton mine, in the Heubach Valley, near Wittichen. It has the hardness 2·5, a density of 3·44, and contains 65·5 per cent. of cobalt oxide and 14·5 per cent. of nickel oxide.—*Neues Jahrbuch für Mineralogie*, 1877, 299.

Sellaite.—Six years ago Strüver discovered a colourless transparent mineral associated with anhydrite at Geibroula, in Piedmont. Small fragments of this mineral were found to melt in the flame of a candle, and to be insoluble in water and in all acids with the exception of sulphuric acid, which caused the evolution of hydrofluoric acid. The acid solution contained 39·64 per cent. of magnesia, and the chemical and physical characters of the mineral led Strüver to regard it as a magnesium fluoride analogous in composition to fluorspar. It received at the time the name given above. Cossa, of Turin, has recently noticed that the white amorphous powder having the composition $Mg\,Fl_2$ separates, after fusion with potassium or sodium chloride, in brilliant crystalline plates. The pure fluoride fuses at the temperature at which cast iron melts, and forms on cooling large crystals having the specific gravity of 2·856, and possessing identically the same form as Strüver's mineral, which he found to be quadratic. Both the mineral and the artificial product are phosphorescent, exhibiting a violet light.

The Origin of Mineral Oils.—At a recent meeting of the Russian Chemical Society, Mendelejeff presented a report on his examination of the deposits of mineral oil in the Caucasus and in Pennsylvania, and propounded a new and interesting theory as to its probable origin. He questioned the accuracy of the view generally held, of the oil being a product of the decomposition of the fossil remains of organisms. The occurrence of the oil near the earth's surface is

to be attributed to the tendency which it possesses to traverse higher and porous sedimentary deposits when exposed to the action of water universally present, and of greater density than itself. The beds of sandstone in which much of the oil is met with do not appear to contain the remains of the organisms to which its origin is ascribed, and the geologist is driven to seek at greater depths the materials which yield it. In the Caucasus the oil occurs in Tertiary beds; in Pennsylvania, in Devonian and Silurian rocks. But, the author maintains, we have no grounds for believing in the occurrence of any extensive deposits of organized structures at a period earlier than the Silurian, and the prevailing view, therefore, can hardly be considered to meet the difficulty. Mendelejeff refers to the theories put forth by Laplace and others respecting the probable mode of formation of our globe, its density as compared with that of the surface layers, so far as we are acquainted with them, &c., and draws attention to the possibility of the interior of the earth containing metallic masses of vast extent. If it be allowed that iron is the prevailing metal—and its presence in great quantities in the sun and in meteorites renders his theory a not improbable one—and that metal occurs in combination with carbon, we have the material from which we can conceive the mineral oil to have been derived. Contact with water at high temperatures, and under great pressure, brought about by the upheaval or disruption of any of the overlying sedimentary strata, would result in the formation of metallic oxides and saturated hydrocarbons. The latter, permeating the porous sandstones of higher levels, would condense there, or, after undergoing further change, become the marsh gas of the "gas-wells," or be converted into unsaturated hydrocarbons. The invariable association of salt water with mineral oil is not without its bearing on this interesting question. If the view recently advanced by Steenstrup, that the remarkable metallic masses, discovered by Nordenskjöld, in 1870, at Ovifak, Disko Island, Greenland, and generally held to be blocks of meteoric iron, be a correct one, and they are really erupted matter and not of cosmical origin, they narrowly resemble, as regards their composition, which analysis has shown to be to a considerable extent carbide of iron and magnetite, the material which Mendelejeff assumes to be the source of the oil.

Ihleite.—Schrauf has given this name to a ferric sulphate which he has found on the graphite of Mugrau, in Bohemia. It is a product of the decomposition and oxidation of the pyrites disseminated through the graphite, and occurs as a fine orange-yellow efflorescence upon its surface; it exhibits the botryoidal characters of botryogen. It has a density of 1·812, and is soluble in cold water. Specimens which were collected in 1875 and the following year were found to have the following composition :—

	1875.		1876.
Sulphuric acid	38·2	37·4	37·2
Iron protoxide	2·1	26·1	1·4
Iron peroxide	24·5		25·6
Alumina		0·3	
Lime		0·4	0·3
Water	35·5	35·6	35.3
	100·3	99·8	99·8

These numbers closely accord with those required by the formula Fe_2O_3 $3SO_3$ $12H_2O$, and ihleite appears to be a distinct mineral species; it differs from the coquimbite, analysed by Gustav Rose, in containing 12 in place of 9 equivalents of water.—*Neues Jahrbuch für Mineralogie*, 1877, 251.

PHYSICS.

The Electric Conductivity of Water.—It seems at first sight curious that in the case of so common a substance as water there should be any doubt among physicists as to the power which the liquid possesses of conducting electricity. Not that the subject has by any means been neglected, as the labours of Magnus, Pouillet, Becquerel, Oberbeck, Rossetti, and Quincke abundantly testify. But the results obtained by these several investigators differ so widely among themselves that it is not easy to know which are to be accepted. The figures brought out by Pouillet, for example, are sixty times greater than those deduced by Magnus. Professor Kohlrausch has, therefore, thought it high time that the subject was settled; and after a most carefully conducted investigation, he has published the results of his inquiry in Poggendorf's "Annalen" (*Ergänzungsb.* iii. 1877, p. 1). Many substances have their electric conductivity affected to a remarkable extent by the presence of impurities, even when these are present in only minute proportion. Matthiessen showed that copper, for instance, has its conductivity lowered 40 per cent. by presence of a mere trace of arsenic. In like manner Kohlrausch has found it necessary to pay scrupulous attention to the purity of the water which he examined, and indeed the discrepancies among the results of previous inquirers may probably be explained by inattention to this point. Having prepared the liquid in as pure a state as the resources of the laboratory can permit, Kohlrausch tested the conductivity by examining a shell of this water enclosed between two hemispherical vessels of platinum nearly fitting one into the other, and serving as electrodes. On passing a current of electricity through this arrangement, it was found that the pure water offered remarkable resistance; in fact its conductivity was only $\frac{1}{120}$ of that assigned to it by Pouillet. Rain, which is, of course, the purest natural form of water, conducted electricity twenty-five times better than the artificially-purified liquid which served as a standard.

Influence of Light on the Electric Resistance of Metals.—Some two or three years ago we were startled by the announcement that the electric conductivity of selenium is capable of being affected by light. It has, however, been since determined that not only selenium but also the allied element tellurium has its electric resistance diminished after exposure to luminous rays. Desirous of determining whether other bodies are similarly affected, Dr. Börnstein has carried out some interesting researches in the Physical Institute at Heidelberg. His results are published in a paper which has been translated by Mr. R. E. Day, in the "Philosophical Magazine" (June, 1877, p. 481). Gold, silver, and platinum are the only metals which Dr. Börnstein has yet examined, but as he finds that all these are sensitive to

light, he is inclined to infer that the property, so far from being exceptional, is one enjoyed in greater or less measure by all metals. In the case of selenium and tellurium, it has been suggested that the alteration of resistance is due to the action of calorific rather than of luminous rays. But no such objection can be urged against the experiments with the noble metals. In fact, the resistance of these metals *increases* with the *temperature*, so that when it is found that on exposure to direct light the resistance is diminished, it is clear that heat can have nothing to do with causing such a change. Heat, indeed, tends to mask the effects of light, and the diminution of resistance is therefore a differential effect; an effect representing the difference between the increase of resistance consequent on rise of temperature, and the decrease of resistance due to the action of light. Dr. Börnstein's experiments, therefore, show beyond question that the electric conductivity of the noble metals is exalted, or their resistance diminished, by the direct effect of luminous rays.

The Electric Candle.—Experiments have been recently conducted at the West India Docks with the view of testing the illuminating power of the so-called electric candle devised by M. Paul Jablochkoff. This simple means of producing a steady electric light consists in placing two carbon pencils side by side, but separated by a bar of a composition called "kaolin." On the passage of the current the carbons slowly burn down, and the kaolin is consumed by the heat at exactly the same rate. The carbons are thus kept always at the same distance apart, and the light playing between them is thus rendered constant without the aid of complex regulators. In the experiments at the West India Docks the current was produced by a magneto-electric machine, worked by a small steam-engine, and the results are described as having been eminently satisfactory. For lights of small and medium size, an apparatus of even greater simplicity may be employed, the carbon points being dispensed with and nothing used beyond a piece of the so-called kaolin held between the electrodes. But M. Jablochkoff's prime improvement, which promises to greatly extend the use of the electric light, consists in his ability to divide the current, so as to supply several candles placed in the same circuit, each with its own coil. These candles may be of various degrees of illuminating power, and may be lighted or extinguished separately. In short, the electricity appears to be under such control, that it might be generated in some central establishment and laid on through wires to the several centres of illumination, just as freely as gas is at present distributed through pipes to any number of burners. MM. Denayrouze and Jablochkoff, who have employed the light in Paris, have described their process before the French Academy of Sciences.—*Comptes rendus*, No. 16, April 17, 1877.

Magnetization of Polarized Light.—It was Faraday who first showed, by a series of famous experiments, that magnetism is capable of exerting a remarkable influence on light which has undergone that physical change which is called polarization. When a beam of plane-polarized light is transmitted through certain transparent media placed between the poles of an electro-magnet, the plane of polarization is rotated in this direction or in that, according to the course which the electrical current is caused to take in circulating through the coils of the magnet. Dr. J. Kerr, of Glas-

gow, reflecting on this fact and others of a kindred nature, was led to institute experiments with the view of determining whether a beam of plane-polarized light, when reflected from an iron surface highly magnetized, would have its plane of polarization twisted in the act of reflection. A paper describing his experiments in detail, and corroborating his assumption, will be found in a recent number of the "Philosophical Magazine" (May, 1877, p. 321). An upright electro-magnet of horse-shoe shape had its polar surfaces polished so as to form reflecting planes. Moreover, a sub-magnet was employed to concentrate the magnetic force, by inductive action, upon the surface of the iron mirror. A beam of light polarized by transmission through a Nicol's prism was incident at various angles upon this mirror, and after reflection was analysed by passing through a second Nicol. Let these prisms be crossed so as to extinguish the light, and then send a current through the electro-magnet; as soon as the iron mirror becomes magnetized the obscuration is diminished, showing, of course, that the plane of polarization has been turned. The direction in which it is turned is contrary to that of the magnetizing current. If, for example, the magnetized iron mirror become a true south pole, then the plane of polarization is turned to the right hand; if the current be reversed, so that the magnet becomes a north pole, the rotation is to the left. It should be remarked that Dr. Kerr, following Sir W. Thomson, uses in this respect a different nomenclature from that popularly employed. His true south pole would be one that points, on the whole, towards the north; that is to say, what most people would call the north pole of the magnet. It seems reasonable enough that the great earth-magnet should have its south pole in the southern, and its north pole in the northern hemisphere. But if artificial magnets are to have their poles similarly named to the like poles of the earth, then (remembering that opposite poles attract) we shall have to call the true south pole of the magnet that which points to the magnetic north; in other words, we reverse the common nomenclature. It is in the highest degree desirable that uniformity should be attained, and confusion prevented, in the use of such common terms. Indeed, it has been suggested to abolish such phrases as the north and south ends of the needle, and to substitute others free from ambiguity.

Method of Determining Index of Refraction.—It is by no means an easy matter to determine the index of refraction of a solid substance, say, of a gem-stone, or other transparent mineral. And yet the refractive power is unquestionably an important physical characteristic, and one which would no doubt be often recorded if it could be measured with readiness. Mr. H. C. Sorby is therefore to be congratulated on placing in our hands a method of extremely simple application ("Mineral. Magazine," No. 4, 1877, p. 97). He takes a small piece of the transparent substance, having flat parallel sides, and placing it on the stage of the microscope, finds the thickness of the fragment, and also the extent to which the focal length of the object-glass is displaced by looking through this thickness of the medium. These measurements are effected by attaching to the body of the microscope a small graduated scale with a vernier, enabling the observer to read off to the thousandth of an inch. To make the two required measurements is but the work of a few moments, and having obtained these data, the index of

refraction is immediately calculated; it is, in fact, equal to the thickness divided by the difference between the thickness and the increase of focal length. By this method Mr. Sorby has already determined the index of refraction of a large number of substances, and has obtained some interesting results. For example, he finds that the mineral called Proustite, or light-red silver-ore, has a refractive exponent as high as 3·28; much higher indeed than that of any substance previously examined. It has been proposed at various times to construct microscopic lenses of diamond or sapphire, but although these gems have very high refractive indices, they are far exceeded in this respect by Proustite. In fact, were it possible to construct a lens of this rare mineral, it would have about twice the magnifying power of a lens of flint-glass of equal curvature. The index of flint-glass is certainly not higher than 1·6, which, as we have seen, is only about half that of Proustite.

The Half-prism Spectroscope.—Instead of the ordinary isosceles prisms used in our spectroscopes, Mr. Christie, of Greenwich, has recently suggested the introduction of half-prisms. By a "half-prism" we understand an ordinary prism which has been cut in half by a plane perpendicular to the base. Such a prism possesses peculiar advantages. Suppose two slightly divergent rays of monochromatic light to pass through an ordinary prism, the angle of separation will not be altered, so that the rays emerge at the same angle to each other which they had at entrance. But if two such rays fall perpendicularly upon a face of the half-prism, the deviation of one ray in traversing the glass will be much greater than that of the other, and they will consequently emerge separated by a much wider angle. In fact, the half-prism is really equivalent to a magnifier with cylindrical lenses. Mr. Christie has had several half-prism direct-vision spectroscopes successfully constructed by Mr. A. Hilger, and has described them before the Physical and Astronomical Societies ("Astron. Register," May, 1877, p. 111). Half a prism of flint-glass is cemented to a half-prism of crown glass, and a combination giving great dispersion is thus obtained. If the double sodium line be viewed through such a spectroscope, the two lines will be seen widely separated, and in consequence of the dispersion they will be broader than with an ordinary instrument. With two such half-prisms a dispersion equal to that of ten compound prisms has been obtained; and this, too, without any loss of definition. Moreover, either great dispersion or great purity of spectrum can be obtained at pleasure, according as the light is allowed to fall first upon the perpendicular or upon the oblique face of the half-prism. Hence by reversing a train of half-prisms, so that the light falls on the opposite side, a comparatively short spectrum is obtained, but one of great purity. Indeed, without use of collimating lenses or slit, the sodium lines may be seen in an ordinary unsalted candle-flame, and Fraunhofer's lines may be seen in the solar spectrum.

The Otheoscope.—So many different forms have been given to the radiometer by the ingenuity of Mr. Crookes, that at the Royal Society's *soirée* in April he was able to exhibit as many as twenty modifications of the little instrument. Among these modifications were several so different from the earlier forms of radiometer, that Mr. Crookes proposes to distinguish them as *Otheoscopes*, a name derived from ὠθέω, I propel. In an ordinary radio-

meter, whatever form it may assume, the glass globe is an essential part of the apparatus. Without the globe the fly would never turn, and the most probable view of the action of the radiometer—the view to which the inventor himself assents—is that rotation must be caused by the excess of molecular pressure between the fly and the enclosing vessel. In the otheoscope, on the contrary, the glass bulb serves merely as an envelope to enclose the rarefied air, and is by no means an essential part of the machinery. In fact, an otheoscope has been constructed without any envelope whatever. Let a radiometer and an otheoscope be removed to a position in space where the air is extremely attenuated, so that the atmospheric pressure is perhaps not more than a millimeter of mercury, and then remove the glass case from each instrument; the fly of the radiometer immediately would become stationary, though there might be abundant solar radiation, but the fly of the otheoscope would whirl round just as merrily as before. The first form of otheoscope described by Mr. Crookes ("Chemical News," May 4, 1877), consists of a four-armed fly, each carrying a vane of thin clear mica. At one side of the glass bulb which encloses the apparatus there is a vertical plate of mica blackened on one face, and so placed that each vane closely approaches it as the mill rotates. If light be allowed to fall only upon the clear vanes, no motion is produced; but if the light shine upon the black plate the vanes instantly begin to rotate, as though repelled by a molecular wind blowing from this surface. The movement is therefore produced by pressure generated on a fixed part of the apparatus, by which the moveable portion is propelled. As this driving-surface is stationary, it is not restricted in weight, size, or shape; and hence the modifications of which the otheoscope admits are well-nigh endless.

The Cycloscope.—It is well known that if a mirror be attached to a vibrating tuning-fork, and a point of light which moves uniformly in a plane at right angles to that in which the fork is vibrating be reflected from this mirror, the image will be an ordinary single wave. Again, if a series of luminous points move uniformly with such velocity that a point passes over two intervals during an odd number of vibrations of the fork, the two waves overlap and produce a double figure of the form of a series of figures-of-eight. Extending these principles, Professor McLeod and Lieutenant G. S. Clarke have recently constructed an ingenious apparatus which has been described before the Royal Society under the name of the cycloscope. Equidistant perforations are made in a circle on a disc, which is attached to a rotating axis, and the light passing through these apertures falls upon a vibrating tuning-fork of known period, whence it is reflected on to a screen; and from the shape of this reflected image the rate of rotation can be deduced. Hence the cycloscope promises to become of much value in determining the speed of machinery. On the contrary, if the speed at which the cylinder rotates be known, the pitch of the tuning-fork may be ascertained.—*Proc. Roy. Soc.*, April 19, No. 180, p. 157.

ZOOLOGY.

A New Larval Cestoid Worm.—In a paper read before the French Academy of Sciences ("Comptes rendus," May 14, 1877), M. A. Villot describes a most interesting larval parasite belonging to the group of Cestoid worms. One of the most remarkable things in connexion with it is the nature of its host, which is a Myriopod, the *Glomeris limbatus*, Lat.; the Cestoid worms in all stages being generally parasitic on vertebrate animals.

In its simplest stage it forms little separate cysts, lodged within the biliary vessels. These cysts, which are about 0·028 mm. in diameter, might easily be mistaken for *Gregarina*-cysts. They are composed of two transparent membranes, and contain two kinds of corpuscles—pale granulations of protoplasmic nature, and very refractive yellowish concretions, such as occur in all Cestoids. Each cyst can reproduce by gemmation after the fashion of a cell, and in this way these vesicles at last completely fill up the lumen of the vessel, forming milk-white masses, visible to the naked eye. The cysts then escape from the vessel into the body cavity, by traversing the wall of the former, to which they generally remain adherent by a pedicle. The multiplication still continues, so that the vessel is soon covered with innumerable cysts of different sizes, but all united by peduncles, and forming bunches, often of considerable size, and of a pearly-white colour.

The vesicles, which are now ovoid, have greatly increased in size, measuring 0·160 mm. in length by 0·140 mm. in breadth. Their envelope has also become thickened; its outer membrane is composed of transverse and longitudinal elastic fibres, forming two distinct layers; and its inner membrane exhibits the ordinary cells of connective tissue. At the anterior pole of the cyst there is a deep funnel-like depression, which is imperforate, and consists solely of a conical invagination of the two membranes. In the interior of the cyst there is a fine, perfectly recognizable *scolex* with four discs, a stout proboscis, and a simple circlet of fourteen hooks. These are 0·026 mm. long and 0·080 mm. broad at the process, which is remarkably developed.

From this description of the scolex there would appear to be no doubt as to the Cestoid nature of this parasite upon *Glomeris*, but so far as we remember the mode of development described is perfectly unique among the Cestoid worms. M. Villot, indeed, says that in its structure and encystation it much resembles the Echinococci; but at the same time he fully recognizes the great differences which separate it from those larval forms, and notices them as follows:—"In the true Echinococci," he says, "the acephalocyst takes no part in the budding, while in the Echinococci of *Glomeris* the budding affects the whole of the cyst and its contents. Hence, in the former case the budding is internal; whilst in the latter it is external. This essential difference in the mode of proliferation" he regards as necessitating the formation of a distinct genus, and he proposes to name the new parasite *Staphylocystis biliarius*, in allusion to the racemose arrangement of the cysts, and the connexion of the parasite with the biliary ducts. It is much to be

wished that the further development of this singular form of parasite may be ascertained. M. Villot states that he also finds a nematoid worm of the genus *Cephalobus* in the stomach of the *Glomeris*, which is very common in the limestone mountains surrounding the city of Grenoble.

Heterogeny in the Gallflies.—It has been long known to entomologists that while of some genera of the delicate little Hymenoptera which produce most of the excrescences on plants known as galls, in which their larvæ live and arrive at maturity, both males and females might always be reared, other nearly allied forms were only known by a single sex, none but females of them having ever been seen. This was strikingly the case with some of the Cynipidæ that infest the oak; and according to a communication made by M. J. Lichtenstein to the Entomological Society of France, Dr. Adler, of Schleswig, has devoted a good deal of attention to the investigation of these little insects, with most curious and interesting results. He finds that the phenomena in question constitute a case of heterogeny; that is to say, the agamic genera, or those of which females only are known, are only transitory forms, producing galls quite different from those from which they themselves issued, and giving origin to both male and female insects. In form and structure these two successive winged generations of the same insects present no resemblance to one another, and do not even belong to the same genus. This certainly constitutes the most remarkable instance of "alternation of generations" with which we are acquainted. Thus the common species, *Spathegaster baccarum*, which issues from the fleshy galls, like white currants, under the leaves of the oak, presents male and female individuals with rather short ovipositors. The females prick the young leaves, and thus give rise to galls quite different from those from which they emerged; namely, the small lenticular or "spangle" galls, from which *Neuroterus lenticularis* proceeds. In the genus *Neuroterus* there are only agamic (female) individuals, which have a very long ovipositor rolled up in the abdomen. They emerge in the winter, and lay their eggs in the buds of the oaks in March and April, thereby causing the formation, not of the lenticular autumn galls, but of the currant-like spring galls from which the *Spathegaster* is produced. Thus both the insects and the galls are exceedingly different. Dr. Adler has ascertained that this relation exists between several species of Cynipidæ, of which the following is a list:—

Neuroterus fumipennis	is the agamic form of	*Spathegaster albipes.*
„ *lenticularis*	„	*Spath. baccarum.*
„ *numismalis*	„	„ *vesicatrix.*
Dryophanta scutellaris	„	*Trigonaspis crustalis.*
„ *longiventris*	„	*Spathegaster Taschenbergi.*
Aphilothrix radicis	„	*Andricus noduli.*

Parthenogenesis in Ants.—In his paper on the habits of ants ("Journ. Linn. Soc.," Zool., Vol. xiii., No. 63), a short notice of which appeared in our last number, Sir John Lubbock refers to the occurrence of true parthenogenesis among those insects. He finds that, as among bees and wasps, the workers occasionally, although rarely, lay eggs. His observations do not enable him to say whether these necessarily unfertilized eggs produce males,

as is known to be the case in bees and wasps, but the following statement would seem to show that they do so. Sir John Lubbock says:—"I have a nest of *Formica cinerea* which I brought from Castellamare, in December 1875, and which has no queen; nevertheless eggs were laid in it last spring, and these eggs produced winged individuals only, all, I believe, males; but, unfortunately, they emerged one day when I was away from home, and I lost the opportunity of examining them carefully. None of the eggs, however, produced workers."

The Lower Sarcode Organisms.—In his Presidential addresses to the Linnean Society for the present year and 1876, Professor Allman has noticed the progress made in the knowledge of those low forms of animals which, consisting almost wholly of undifferentiated sarcode, may be looked upon as occupying the very lowest step in the series of animal organisms, even if we decline to refer them, with Häckel, to the neutral group of the Protista. The address for 1876 is just published in full in the "Journal" of the Society; it is fully illustrated, and contains an admirable summary of the results of recent researches upon the lowly organisms of which it treats.

In his address delivered on the 24th of May last Professor Allman remarked that to the investigations of Archer and others in this country, and of Hertwig, Lesser, Schulze, and Greeff, in Germany, much of our knowledge of the Monothalamic Rhizopods of freshwater is due. These latter forms may be divided in accordance with the nature of their pseudopodia, in some these processes being short, thick, and finger-shaped (Lobosa); in others long slender threads (Filifera).

Quadrula with a sculptured shell illustrates the former, and the still more curious *Microgromia socialis* the latter. This last forms colonies united by a network of gelatinous threads. Moreover, Hertwig has shown that the protoplasm of *M. socialis* divides by spontaneous fission into two segments, one of which remains in the shell; the other, forcing its way out, assumes an oval shape, and develops vibratile flagella, and not pseudopodia, thus becoming a free-swimming flagellate zoospore capable of ultimate development into the adult form. The importance of Häckel's discovery that starch is contained in the so-called "yellow cells" of the Radiolaria was referred to. Messrs. Dallinger and Drysdale have shown that the flagellate monads may acquire an amœboid condition, and move about by the aid of pseudopodia; that two such amœboid forms, when they come in contact with one another, become instantly blended together at the point of contact, and ultimately fused together throughout, when their mingled protoplasm assumes the form of a spherical sac filled with particles of immeasurable minuteness. These particles are germs destined for the reproduction of the individual. Their form can be demonstrated only by the highest powers of the microscope, such as the 1-50 inch object-glass. Not only has their development into the adult form been traced, but the unexpected fact has been elicited that these germs can be subjected to a temperature of 258°-300° Fahr. without losing their vitality and power of development—a fact of vast significance in its bearing on experiments connected with the question of spontaneous generation. Hertwig and Schulze have quite recently made the discovery of a nucleus in the Foraminifera. This group, therefore, must now be removed from the region of Cytodes, or non-nucleated protoplasmic masses, and

placed in a higher stage in the great division of the Rhizopoda. From facts such as these F. E. Schulze conceives he has got a clue to the affinities and derivation of the various members of the Sarcode organisms, Rhizopoda. The primitive forms, non-nucleated Cytodes, Häckel's Monera (*Protogenes*, *Protamœba*, &c.), Schulze regards as the lower undivided stem. From these, by differentiation of a nucleus in their protoplasm, are evolved the nucleated forms (*Amœba*, freshwater Monothalamia, Foraminifera, Heliozoa, &c.), which constitute the subdivisions into which the stem branches off. These repeat the various modifications of pseudopodia (Lobose, Filiform, &c.), which have already existed in the primitive forms, and which they thus derive by inheritance from their non-nucleated progenitors. Finally, through the branch of the Heliozoa, we are conducted to the ultimate twigs formed by the families of the Radiolaria, in which we find not only nuclei but a "central capsule," indicating the highest grade attained by any member of the group.

The so-called "Colonial Nervous System" of the Polyzoa.—In 1860, Fritz Müller described a series of cords with ganglionic inflations which he had found traversing the stem and branches of the polyzoary in *Serialaria Coutinhii*, a polyzoan of the Brazilian coast, and which he regarded as a "colonial nervous system" destined to transmit sensations to different parts of the common structure, and probably to govern the movements of the zooids. Other observers, especially Smitt and Claparède, detected something of the same kind in European species of Cheilostomatous Polyzoa, and M. L. Joliet has recently communicated to the French Academy of Sciences ("Comptes rendus," April 9, 1877), the results of his observations on *Bowerbankia imbricata*, Johnst., a species which, with its congener, *B. densa*, Farre, is particularly well adapted for such investigations.

The colonial nervous system in *Serialaria*, as described by Fritz Müller, consists of the following parts:—1. A central cord which traverses the length of each joint of the stem, and divides distally into as many branches as the joint gives off ramifications; 2. Granular ganglia placed at the bases of the branches and of the zoœcia, or cells of the individual polypides; 3. A plexus superadded to the central cord and uniting the ganglia of the branches and zoœcia; 4. A nerve which runs from the ganglion at the base of each zoœcium to the bud and to the intestine of the adult polypide. All these parts are equally distinct in *Bowerbankia imbricata*, but some of them bear a very different interpretation from the above.

In this species, according to M. Joliet, the central cord consists of large fusiform cells, not containing a distinct nucleus, but a very variable number of refractive granules. These cells agree with no known nervous element. The plexus possesses the same structure as the central cord; and its branches, instead of running to some particular point, or to some organ, such as the muscles, generally go to indeterminate points in the walls of the cell where there would appear to be no movement to produce or sensation to perceive, and here, instead of forming something like an ordinary nervous termination, they become confounded with the endocyst. With regard to the ganglia, Fritz Müller would appear to have been misled by appearances. According to M. Joliet, at the level of the articulations there are diaphragms, which have been already noticed by Reichert in *Zoobotryon pellucidus*, and which cut

the supposed ganglia into two parts, communicating only by a narrow perforation in the diaphragm. The so-called ganglia are, in fact, simply appearances produced by the juxtaposition on the two surfaces of a thin diaphragm of two masses of granular matter produced by the spreading out, on these surfaces, of the central cord of the corresponding joint.

The supposed nerve which runs from the basal ganglion of the zoœcium to the bud is actually attached, as Fritz Müller thought, to the intestine of the adult polypide, but, according to M. Joliet, it is nothing but the organ described by previous authors under the name of the *funicle*. It has the same structure as the central cord, and it is so contractile as to act the part of a third retractor muscle. It has therefore no resemblance to a nerve.

From all these circumstances M. Joliet concludes that this system of organs is not nervous in its nature. Further, he finds by experiment that pinching or even cutting the central cord has no influence upon the polypides which might be expected to be acted upon, and hence concludes that it does not transmit sensation. He is still engaged in investigating its nature, but in the meantime states that the fusiform cells of which it is composed may often be seen to swell and become rounded, and then detach themselves from their neighbours, giving origin to a number of floating corpuscles which are observed in the liquid filling the joints of the stem and the cavities of the zoœcia of the *Bowerbankia*. As these Polyzoa are found on the British coasts, some of our readers may find an interest during the coming vacation time in investigating this curious problem.

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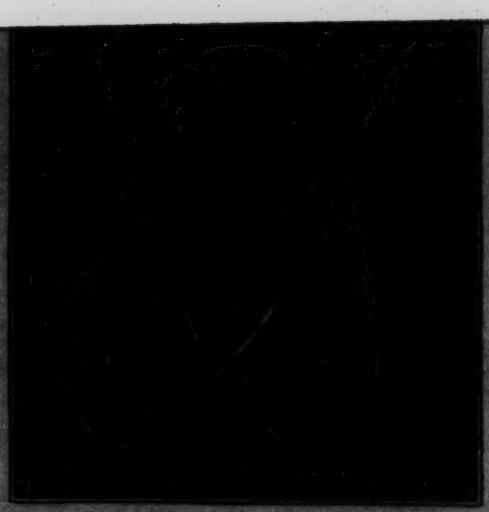

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